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Pavement Management Forecasting Model

A Microcomputer Program For Lotus 1-2-3

MAPC
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Planning Council**
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CREDITS

This software and documentation were developed as part of the Metropolitan Area Planning Council's analysis of Funding the Rehabilitation and Reconstruction of Locally-Maintained Roads in the MAPC Region. The entire project was funded directly by the 101 member communities of MAPC.

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PAVEMENT MANAGEMENT FORECASTING MODEL

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OVERVIEW OF THE PAVEMENT MANAGEMENT FORECASTING MODEL

PURPOSE: To estimate funds needed to repair locally-maintained roads by simulating the contest between pavement deterioration and roadway maintenance procedures; to produce 10-year forecasts of road conditions and of the cumulative maintenance backlog

DESIGN:

Inputs:
- Road maintenance and construction unit costs [Default values provided]
- Pavement deterioration rates [Default values provided]
- Estimated future funding for roadway improvements
- Current road conditions
- Choice of roadway repair strategies

Outputs:
- Summary of estimates and assumptions on which each forecast is based
- Summary of forecast results
- Annual road conditions, maintenance backlog, and work plan
- Tabular and graphic presentations of road conditions and maintenance backlog over a 10-year period

Environment: Program written in Lotus Command Language for use with Lotus 1-2-3, Release 2, on the IBM PC, XT, AT, or "IBM-compatible" computer.

DATA ENTRY: NOTE: THE MODEL IS COMPLETELY AUTOMATIC, PROMPTING THE USER FOR NECESSARY INPUT AND USING DEFAULT VALUES IF CONTINUING WITHOUT MAKING A NUMERIC ENTRY.

Construction costs:
- Surface Treatments [Default = $11,300 per mile]
- Rehabilitation [Default = $86,300 per mile]
- Reconstruction [Default = $259,900 per mile]

Deterioration rates:
- Excellent pavement becomes good in _ years [Default = 10]
- Good pavement becomes fair in _ years [Default = 5]
- Fair pavement becomes poor in _ years [Default = 2]

Future funding: Your estimates for total funds available for roadway improvements (surface treatments, rehabilitations, and reconstruction projects only) for each of ten years [Default = $0]

Road Conditions: May be entered either by the number of miles or by the percentage of the total miles in each condition. [Default = 0.00]

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Repair Strategy: Choice of three strategies:

Percentage-based Approach - general approach, dividing repair costs between the three repair procedures so that the percentage of miles repaired is comparable, in percentage, to the number of miles in that condition

Best-first approach - concentrate spending on surface treatments first, repairing good and fair roads while allowing poor roads to deteriorate further

Worst-first approach - reconstruct poor roads first, allowing good and fair roads to continue to deteriorate

OPTIONS: Several options may be selected from the menu following data entry, allowing the user to further focus the model to individual needs. These options include displaying summaries of the inputs and results, editing the inputs or the output form, and printing the results.

DEFINITIONS

ROAD CONDITIONS [Definitions from *Pavement Management: A Manual for Communities*, MAPC, 1986]

Excellent - new or nearly new pavement with little or no distress; no repairs necessary

Good - some pavement distress but few visible signs of surface deterioration; treatable with sealing and patching

Fair - pavement displaying moderate distress and a riding quality noticeably inferior to new pavements and may be barely tolerable for high-speed traffic

Poor - extensive distress or near complete failure; pavements deteriorating to such an extent that they are in need of extensive resurfacing or complete reconstruction

ROADWAY REPAIR PROCEDURES

Surface Treatments - crack fills, seals, patching, or other procedures that improve a good road to excellent condition

Rehabilitation - resurfacing and overlays; restores a fair road to excellent condition

Reconstruction - complete reconstruction of the roadway; improves a poor road to excellent condition

ROADWAY REPAIR STRATEGIES - Methods for prioritizing and dividing expenditures among the three repair procedures

Percentage-based Approach - repair costs are divided among the three repair procedures so that the percentage of miles repaired is comparable in percentage to the number of miles in the corresponding condition during the previous year

Best-first Approach - concentrate spending on surface treatments first, repairing good and fair roads first while allowing poor roads to deteriorate further

Worst-first Approach - reconstruct the worst roads first, allowing good and fair roads to deteriorate to poor condition

DETERIORATION RATES - The length of time (in years) in which pavement deteriorates from one condition to the next lower condition

FUTURE FUNDING - The estimated amount of funding available each year for surface treatments, rehabilitation, and reconstruction of roadways. Excludes costs such as snow removal and routine maintenance.

MAINTENANCE BACKLOG - The dollar amount which would improve all roads to excellent condition at a given time.

SOURCES OF DEFAULT VALUES

CONSTRUCTION COSTS: The default values for construction costs are based on information from the following sources:

Street and Maintenance Manual, American Public Works Association (APWA), 1985.

Road Surface Management for Local Governments: A Course Workbook, Federal Highway Administration (FHWA), 1985.

An Analysis of the Economic Benefits of a Highway Repair Program in Massachusetts, prepared by The Road Information Program (TRIP) for Construction Industries of Massachusetts, Inc., 1982.

"The Decision-Making Process Related to Pavement Rehabilitation," David Kraus, Chief Engineer, Town of West Hartford, Connecticut, February 24, 1984.

Pavement Evaluation Report for the Town of Holliston, Massachusetts, Kenneth Garrity, Superintendent, 1983.

Preliminary Engineering Study of Bituminous Pavements in Wenham, Massachusetts, Nathan Wiseblood, Private Consultant, 1985.

Pavement Management Plan and Priority Programming, prepared for the Burlington Department of Public Works by Vanasse/Hangen Associates, Inc. and Tippetts-Abbott-McCarthy-Stratton, 1985.

Town of Reading, Massachusetts, Roadway Maintenance Program, William R. Bergeron, Assistant Superintendent, Engineering Division, Department of Public Works.

DETERIORATION RATES: The default values for deterioration rates are derived from the pavement deterioration curve in The Hole Story (American Public Works Association [APWA]) and assumes a pavement design life of twenty years.

INTRODUCTION

Purpose/use

The Pavement Management Forecasting Model is an easy-to-use, quick response forecasting model. Developed to estimate the funds needed to maintain and repair locally-maintained roads, the mathematical model assumes simple relationships to simulate the contest between pavement deterioration and roadway repairs. It produces 10-year forecasts of road conditions and calculates the maintenance backlog of the road network.

Design

INPUTS

The model is completely automatic and fully user-interactive, prompting the user for inputs of the following information:

Road Maintenance and Construction Unit Costs;
Pavement Deterioration Rates;
Estimated Future Funding for Highway Improvements; and
Current Road Conditions.

Also to be entered is the choice of a road repair strategy from three options included in the model.

Default values for construction costs and deterioration rates are also included in the model and are based on estimates from various expert sources. The model also provides the option of editing the inputs, making it easy to experiment with several different scenarios.

OUTPUTS

The model returns summaries of the inputs and the results to the screen, as well as graphs of road conditions and the maintenance backlog over the 10-year period. Also available, through the Options menu, is a printed report which includes the following information:

A summary of the current inputs;
Annual results of road conditions, maintenance backlog, and
  the work plan based on the repair strategy; and
A summary of the forecasted results.

Graphs of road conditions and the maintenance backlog over the 10-year period can also be printed as part of the output.

INSTALLATION

Environment

The program is written in Lotus Command Language for use with Lotus 1-2-3, Release 2, on the IBM PC, XT, AT, or "IBM-compatible computer: with an appropriate version of DOS and a monitor capable of displaying Lotus 1-2-3 graphs. A printer is not essential to run the program but is necessary for complete output.

Startup

TWO-DISKETTE SYSTEM

Follow these instructions if your system has two diskette drives:

1. Start your computer using appropriate DOS for Lotus 1-2-3, Release 2
2. After entering the current date and time, the DOS prompt appears (A>) (If the DOS prompt is not A>, type A: <-|). At this point, place the Lotus 1-2-3 System Disk in the default drive (Drive A) and the program disk in Drive B and close the doors
3. To start the model, type B:MODELa <-|

HARD-DISK SYSTEM

NOTE: THESE INSTRUCTIONS ARE BASED ON THE ASSUMPTION THAT LOTUS 1-2-3, RELEASE 2, IS CONTAINED IN A SUBDIRECTORY NAMED \123 ON THE HARD DISK (DRIVE C) AND THAT THE DEFAULT DIRECTORY OF LOTUS 1-2-3 IS THE MAIN DIRECTORY OF THE HARD DISK (DRIVE C). IF YOUR SYSTEM IS NOT CONFIGURED IN THIS MANNER OR IF YOU ARE NOT SURE, PLEASE REFER TO THE INSTALLATION SECTION OF THE TECHNICAL APPENDIX.

Follow these instructions if your system has a hard-disk configured as noted above:

1. Start your computer using appropriate DOS for Lotus 1-2-3, Release 2, entering the date and time
2. Make the hard disk the "default drive" (The DOS prompt should be C>. If it is not, type C: <-|)
3. Place the program disk in the diskette drive (Drive A) and close the door
4. To start the model, type A:MODEL <-|

DATA ENTRY

WARNING: ENTER DATA ONLY AT THE PROMPTS. BE CAREFUL NOT TO STRIKE ANY EXTRANEOUS KEYS DURING DATA ENTRY AS THIS MAY RESULT IN EITHER THE SELECTION OF THE DEFAULT VALUES OR THE BYPASSING OF THE RESULTING GRAPHS.
ALSO, DATA ENTERED ACCIDENTLY CANNOT BE CHANGED UNTIL THE EDIT OPTION AVAILABLE LATER IN THE MODEL.

NOTE: Default values may be selected by striking RETURN

Construction Costs: At the prompts (at the top of the screen), enter estimates of the costs per mile for surface treatments [Initial default = $11,300], rehabilitation [Initial default = $86,300], and road reconstruction [Initial default = $259,900]

Deterioration rates: At the prompts, enter estimates of pavement deterioration rates (in whole years and assuming no preventative maintenance) [Initial default values: Excellent pavement becomes good in 10 years, good pavement becomes fair in 5 years, and fair pavement becomes poor in 2 years.] Further deterioration of poor roads is not included in the model.

Future Funding: At the prompts, enter estimates of future funds available for highway improvements (Surface treatments, rehabilitations, and reconstruction projects only. Do not include costs associated with routine maintenance, snow removal, lighting, etc.) [Initial defaults = $0]

Road Conditions: Current road conditions may either be entered by the number of miles in each condition or by the percentage of the total miles in each condition. If entering by the number of miles in each condition, enter estimates for each condition at the prompts. [Initial defaults = 0.00]
If entering by percentages, first enter the number of total miles, then enter estimates for each condition. (Percentages should be entered in integer form) [Initial defaults = 0.00]

Repair Strategy: Choose between the following three general roadway repair strategies:

Percentage-based Approach - Repair costs are divided among the three procedures so that the number of miles repaired is comparable in percentage to the number of miles in the corresponding condition during the previous year.

EXAMPLE:

If the road conditions during the previous year are:			Then, depending on costs and funding, the work plan could be:	
Exc.	40 mi			
Good	30 mi	------->	Surf. Treat.	3 mi
Fair	20 mi	------->	Rehab.	2 mi
Poor	50 mi	------->	Recon.	5 mi

Best-first Approach - Concentrate spending on surface treatments and rehabilitation first, repairing good and fair roads first while allowing poor roads to deteriorate further, possibly to complete failure.

Worst-first Approach - Reconstruct the worst roads first, allowing the excellent and good roads to deteriorate to poor condition.

NOTE: After entering all the initial data, the model will run and, after a short wait, will return graphs of the road conditions and maintenance backlog. To continue from a graph, strike any key. BE CAREFUL TO STRIKE ONLY ONE. ADDITIONAL KEYSTROKES MAY RESULT IN BYPASSING A GRAPH.

OPTIONS

The following options may be selected from the main options menu after entering the data by either typing the first letter or moving the highlight bar (using the space bar or the arrow keys) and pressing RETURN: (Pressing ESCAPE will return the user to the previous menu)

Summary: Displays a summary of the current inputs.

Results: Displays a summary of the yearly results including road conditions and maintenance backlog.

Edit: Allows the user to alter any or all of the data entered. During Edit mode, pressing RETURN selects the displayed value. After editing an input, another menu appears:

Edit: Allows the user to change additional inputs.
Rerun: Reruns the model using all the updated inputs; the summary screen is displayed, then the resulting graphs (strike any key to continue from a graph) before returning to the main options menu.
Quit: Returns to the main options menu without rerunning the model. (THE MODEL MUST BE RERUN FOR ANY DATA CHANGES TO BE INCLUDED IN THE RESULTS)

Print: Prints out a report of the model's inputs and results. NOTE: The program is written so that part of the report is printed in compressed print. If your printer does not have compressed print capability, 11" x 14" paper should be used. To change any of the print settings, please refer to the Program Alterations section of the Appendix.

Align: Resets the alignment of the paper to the top of the page.
Go: Begins the printing process. After the report is printed, the user is returned to the main options menu.
Quit: Returns to the main options menu without printing the report.

Graph: Allows the user to edit, view, or save/print selected graphs. (Either the road conditions graph or the maintenance backlog graph or both can be selected).

Edit: Allows changes to the graph titles and/or subtitles. After selecting which graph(s) to edit, the graph(s) is/are displayed (Strike any key to continue from a graph). Then, at the prompt(s), enter the new title or subtitle.
View: Allows the user to view the selected graph(s). (To continue from a graph, strike any key)

Save: Allows the user to save the selected graph(s) on Drive B for later printing.

After selecting which graph(s) to save, the graph(s) is/are displayed (Strike any key to continue from a graph). At the prompt(s), enter the file name in which to save the graph. The file name can contain up to eight characters and can include uppercase and lowercase letters, numbers, and the underscore character (_). Space characters and special characters (/,@,|, etc.) are not accepted. If you are using a hard-disk system, there will be a prompt to insert a disk for the B Drive. Insert a new disk and hit any key to save the graphs on a separate disk or just hit any key to save the graphs on the program disk. (On quitting the model, there will be a prompt to insert a disk for Drive A. If you saved the graphs on the program disk, just hit any key; if you used another disk, place the program disk in Drive A.) If you are using a two-disk system, the graphs will automatically be saved on the program disk. (If you wish to save the graphs in a drive other than B, please refer to the Miscellaneous section of the Appendix.)

To print the graph, quit the model and use Lotus PrintGraph.

From the Lotus Access menu, select PrintGraph.

First, make sure the Graphs Directory is set to B:

To set the Graphs Directory to B:, from the main PrintGraph menu, select:

Settings   Hardware   Graphs-Directory

and type B: <-|

Return to the main menu by

Quit   Quit

Use Image-Select to select the graphs you named earlier

Align after adjusting the paper in the printer, then

Go to print the graph. (It may take a few minutes to finish printing the graph.)

For more complete and detailed information about other options in the PrintGraph program, please refer to the Lotus 1-2-3 manual.

Quit: Returns the user to the main options menu.

Quit: Returns the user to the Lotus Access menu.

PAVEMENT MANAGEMENT FORECASTING MODEL

TECHNICAL APPENDIX

PAVEMENT MANAGEMENT FORECASTING MODEL

TECHNICAL APPENDIX

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MODEL AND PROGRAM DESCRIPTIONS

The Pavement Management Forecasting Model is a combination of eight files designed for use with Lotus 1-2-3, Release 2, and an appropriate version of DOS. The files, contained on the program disk, are:

MODEL.BAT
MODELa.BAT
DEFA.BAT
AUTO123.WK1
LOGO.TXT
MENU1.TXT
MENU2.TXT
MENU3.TXT

The batch files (file extension .BAT) contain the instructions which run the model during DOS. (The batch file used depends upon the type of system which is being used.) The text files (extension .TXT) contain the four introductory screens of the model. Most of the model, however, is contained in the Lotus worksheet file (AUTO123.WK1).

Upon beginning the model, either by typing B:MODELa on a two-disk system or A:MODEL on a system with a hard-disk, the instructions of the corresponding batch file are executed. After requesting the current date, the model continues through the four introductory text screens, pausing after each screen for a keystroke before continuing. After the introduction, the model enters Lotus 1-2-3 and automatically retrieves the worksheet file (AUTO123.WK1). This file has two major components, the controlling program and the forecasting calculations, which are described below. (A diagram of the layout of the worksheet is included in the Structure Diagrams section of the Appendix.)

Controlling Program: The model continues with the controlling program which is written in Lotus Command Languages as an automatically executing macro. The program controls the input of data and the output of results, directing the user through six data entry screens which are located in the worksheet. The program automatically positions the cursor at the appropriate position for the input and prompts for the needed information. Default values can be selected by striking RETURN without entering any other data. Necessary directions are included throughout the data entry session to inform the user of the status of the program. After the information is entered, the program then calculates the road conditions and the maintenance backlog for each of the 10 years and displays graphs of both over the ten year period. (See page A2 for a description of the forecasting calculations.) After displaying the graphs, the Main Options menu appears, allowing the user several options. These options are:

Summary - displays a summary of the current inputs
Results - displays a summary of the yearly road conditions and maintenance backlog
Edit - allows the alteration of any or all inputs
Print - prints out a report of the results
Graph - allows the user to edit titles, view, or save (for later printing) selected graphs
Quit - return to the Lotus Access menu

Upon selection of a menu command, the program branches to execute that command. The commands of EDIT, PRINT, and GRAPH have submenus that further branch the program. (See the Structure Diagrams section of the Appendix for a diagram of the menus.) Completion of a command returns the program to the Main Options menu for further commands. (Refer to the Annotated Program section of the Appendix for a complete, step-by-step description of the program.)

Forecasting Calculations: This section of the worksheet uses the entered data and performs calculations to forecast future road conditions and maintenance backlog.

Beginning with the current road conditions, the model calculates the annual work plan based on the construction costs, estimated funding, and repair strategy. The work plan is determined by the following formulas:

Percentage-Based Approach:

$$ST = \frac{EAF}{ST\$ + Rh\$ \times (F/G) + Rc\$ \times (P/G)}$$

$$Rh = \frac{EAF}{ST\$ \times (G/F) + Rh\$ + Rc\$ \times (P/F)}$$

$$Rc = \frac{EAF}{ST\$ \times (G/P) + Rh\$ \times (F/P) + Rc\$}$$

Best-first Approach:

$$ST = \frac{EAF}{ST\$} \quad \text{if} \quad G \times ST\$ > EAF$$

$$= G \quad \text{otherwise}$$

$$Rh = \frac{EAF - G \times ST\$}{Rh\$} \quad \text{if } ST = G \text{ and } (EAF - G \times ST\$) < F \times Rh\$$$

$$= F \quad \text{if } ST = G \text{ and } (EAF - G \times ST\$) > F \times Rh\$$$

$$= 0 \quad \text{otherwise}$$

$$Rc = \frac{EAF - G \times ST\$ - F \times Rh\$}{Rc\$} \quad \text{if } Rh = F \text{ and } (EAF - G \times ST\$ - F \times Rh\$) < P \times Rc\$$$

$$= P \quad \text{if } Rh = F \text{ and } (EAF - G \times ST\$ - F \times Rh\$) > P \times Rc\$$$

$$= 0 \quad \text{otherwise}$$

Worst-first Approach:

$$Rc = \frac{EAF}{Rc\$} \qquad \text{if} \quad P \times Rc\$ > EAF$$

$$= P \qquad \text{otherwise}$$

$$Rh = \frac{EAF - P \times Rc\$}{Rh\$} \qquad \text{if } Rc = P \text{ and } (EAF - P \times Rc\$) < F \times Rh\$$$

$$= F \qquad \text{if } Rc = P \text{ and } (EAF - P \times Rc\$) > F \times Rh\$$$

$$= 0 \qquad \text{otherwise}$$

$$ST = \frac{EAF - P \times Rc\$ - F \times Rh\$}{ST\$} \qquad \text{if } Rh = F \text{ and } (EAF - P \times Rc\$ - F \times Rh\$) < G \times ST\$$$

$$= G \qquad \text{if } Rh = F \text{ and } (EAF - P \times Rc\$ - F \times Rh\$) > G \times ST\$$$

$$= 0 \qquad \text{otherwise}$$

Where:
ST = Number of mile repaired with surface treatments
Rh = Number of mile rehabilitated
Rc = Number of miles reconstructed
EAF = Estimated annual funding
ST$ = Costs (per mile) of surface treatments
Rh$ = Costs (per mile) of rehabilitation
Rc$ = Costs (per mile) of reconstruction
G = miles in good condition (during previous year)
F = miles in fair condition (during previous year)
P = miles in poor condition (during previous year)

Conditions:
$ST <= G$
$Rh <= F$
$Rc <= P$

Using the inputted deterioration rates, the model also calculates the number of road miles that deteriorate from each condition during each year. The model assumes that the age of the pavements in each condition is uniformly distributed (i.e. If a good road deteriorates to fair in 5 years, 20% of the good pavements will become fair in the next year, and, if left unmaintained, all the current roads in good condition will be in fair (or poor) condition in 5 years).

The model then applies the work plan and the deterioration results to calculate the new road conditions. It then uses these road conditions and calculates the next year's results, continuing this process throughout the ten year period.

EXAMPLE:

Initial Road Conditions	
Exc.	40 mi
Good	30 mi
Fair	20 mi
Poor	50 mi

Deterioration Rates

Excellent becomes good in 10 years
Good becomes fair in 5 years
Fair becomes poor in 2 years

Construction Costs		Est. Funding	Resulting Work Plan (%-based)	
Surface Treat.	$10,000		Surface Treat	3 mi
Rehab.	35,000	$600,000	Rehab.	2 mi
Recon.	100,000		Recon.	5 mi

Road Conditions

	Initial	Change (Deterioration)	Change (Work Plan)	Resulting
Exc.	40 mi	-4	+10	46 mi
Good	30 mi	+4 -6	-3	25 mi
Fair	20 mi	+6 -10	-2	14 mi
Poor	50 mi	+10	-5	55 mi
TOTAL	140 mi	0	0	140 mi

ANNOTATED PROGRAMS

BATCH FILE PROGRAMS

MODELa.BAT (used with a two-disk system)

```
ECHO OFF                      suppresses prompt and command display
CLS                           clears the screen
DATE                          prompts for date
TYPE B:LOGO.TXT               displays the logo
PAUSE                         waits for a keystroke
CLS                           clears the screen
TYPE B:MENU1.TXT              displays the first intro. screen
PAUSE                         waits for a keystroke
CLS                           clears the screen
TYPE B:MENU2.TXT              displays the second intro. screen
PAUSE                         waits for a keystroke
CLS                           clears the screen
TYPE B:MENU3.TXT              displays the third intro. screen
PAUSE                         waits for a keystroke
CLS                           clears the screen
123                           loads Lotus 1-2-3
LOTUS                         returns the Lotus Access menu
```

MODEL.BAT (used with a hard-disk system)

```
ECHO OFF                      suppresses prompt and command display
CLS                           clears the screen
DATE                          prompts for date
TYPE A:LOGO.TXT               displays the logo
PAUSE                         waits for a keystroke
CLS                           clears the screen
TYPE A:MENU1.TXT              displays the first intro. screen
PAUSE                         waits for a keystroke
CLS                           clears the screen
TYPE A:MENU2.TXT              displays the second intro. screen
PAUSE                         waits for a keystroke
CLS                           clears the screen
TYPE A:MENU3.TXT              displays the third intro. screen
PAUSE                         waits for a keystroke
CLS                           clears the screen
A:DEFA                        branches to A:defa.BAT
```

DEFA.BAT

```
COPY A:AUTO123.WK1 C:AUTO123.WK1   copies the woksheet file to
                                   the default directory
C:                          changes to the hard drive
CD \123                     changes to the directory containing 123
123                         loads Lotus 1-2-3
CD \                        return to the hard-disk main directory
DEL AUTO123.WK1             deletes the automatic woksheet from the
                              hard disk
CD \123                     changes to the directory containing 123
LOTUS                       returns the Lotus Access menu
CD \                        return to the hard-disk main directory
```

ANNOTATED PROGRAM

MAIN MACRO (automatically executing)

```
\0          {PANELOFF}{WINDOWSOFF}{BREAKON}{ONERROR OOPS}                     initialize screen
            /WGRM                                                             set recalc to manual
            {BLANK AV9}{BLANK AV14}{BLANK AV19}                               initialize worksheet
            {BLANK BB12..BB16}{BLANK AV30..AV39}{BLANK AV72}                  initialize worksheet
            {BLANK AV54..AV57}{BLANK AV75..AV78}{BLANK Z1..Z2}                initialize worksheet
            {GOTO}Z5~11300{DOWN}86300{DOWN}259900                             set defaults (const. costs)
            {DOWN}10{DOWN}5{DOWN}2{DOWN}0{DOWN}0{DOWN}0{DOWN}0~               set defaults (d rates, rd cond)
            {CALC}/WGDDqw{ESC}B:~Q                                            set default drive to B
            {CC}{DR}{AE}{RCC}{STRAT}{GRPH}{VIEW}{MBRANCH}                     call subroutines
```

CONSTRUCTION COSTS INPUT SUBROUTINE (called from main macro)

```
CC          {GOTO}AT1~{DOWN 8}{RIGHT 2}{WINDOWSON}{INDICATE INPUT}            initialize screen
            {GETNUMBER "Per mile cost of surface treatments? [Hit RETURN for default] ",AV9}~        prompt
            {IF AV9=0}/CZ5~AV9~                                               get default
            {RECALC AQ1}{IF AQ1=1}/CZ5~AV9~                                   get default
            {DOWN 5}                                                          move cursor
            {GETNUMBER "Per mile cost of rehabilitation? [Hit RETURN for default] ",AV14}~           prompt
            {IF AV14=0}/CZ6~AV14~                                             get default
            {RECALC AQ2}{IF AQ2=1}/CZ6~AV14~                                  get default
            {DOWN 5}                                                          move cursor
            {GETNUMBER "Per mile cost of reconstruction? [Hit RETURN for default] ",AV19}~           prompt
            {IF AV19=0}/CZ7~AV19~                                             get default
            {RECALC AQ3}{IF AQ3=1}/CZ7~AV19~                                  get default
            {WINDOWSOFF}/CAV9~Z5~/CAV14~Z6~/CAV19~Z7~                         reset defaults
            {INDICATE}{RETURN}                                                return to main macro
```

DETERIORATION RATES INPUT SUBROUTINE (called from main macro)

```
DR          {GOTO}AY1~{DOWN 11}{RIGHT 3}{WINDOWSON}{INDICATE INPUT}           initialize screen
            {GETNUMBER "Years until excellent pavement becomes good? [Hit RETURN for default] ",BB12}~prompt
            {IF BB12=0}/CZ8~BB12~                                             get default
            {RECALC AQ4}{IF AQ4=1}/CZ8~BB12~                                  get default
            {DOWN 2}                                                          move cursor
            {GETNUMBER "Years until good pavement becomes fair? [Hit RETURN for default] ",BB14}~     prompt
            {IF BB14=0}/CZ9~BB14~                                             get default
            {RECALC AQ5}{IF AQ5=1}/CZ9~BB14~                                  get default
            {DOWN 2}                                                          move cursor
            {GETNUMBER "Years until fair pavement becomes poor? [Hit RETURN for default] ",BB16}~     prompt
            {IF BB16=0}/CZ10~BB16~                                            get default
            {RECALC AQ6}{IF AQ6=1}/CZ10~BB16~                                 get default
            {WINDOWSOFF}/CBB12~Z8~/CBB14~Z9~/CBB16~Z10~                       reset defaults
            {INDICATE}{RETURN}                                                return to main macro
```

ESTIMATED FUNDING INPUT SUBROUTINE (called from main macro)

```
AE        {GOTO}AT21~{DOWN 9}{RIGHT 2}{WINDOWSON}{INDICATE INPUT}                   initialize screen
          {GETNUMBER "Expenditure in Year 1: ",AV30}                                 prompt
          {RECALC AP1}{IF AP1=1}/CAW30~AV30~                                         get default
          {DOWN}{GETNUMBER "Expenditure in Year 2: ",AV31}                           move cursor, prompt
          {RECALC AP2}{IF AP2=1}/CAW31~AV31~                                         get default
          {DOWN}{GETNUMBER "Expenditure in Year 3: ",AV32}                           move cursor, prompt
          {RECALC AP3}{IF AP3=1}/CAW32~AV32~                                         get default
          {DOWN}{GETNUMBER "Expenditure in Year 4: ",AV33}                           move cursor, prompt
          {RECALC AP4}{IF AP4=1}/CAW33~AV33~                                         get default
          {DOWN}{GETNUMBER "Expenditure in Year 5: ",AV34}                           move cursor, prompt
          {RECALC AP5}{IF AP5=1}/CAW34~AV34~                                         get default
          {DOWN}{GETNUMBER "Expenditure in Year 6: ",AV35}                           move cursor, prompt
          {RECALC AP6}{IF AP6=1}/CAW35~AV35~                                         get default
          {DOWN}{GETNUMBER "Expenditure in Year 7: ",AV36}                           move cursor, prompt
          {RECALC AP7}{IF AP7=1}/CAW36~AV36~                                         get default
          {DOWN}{GETNUMBER "Expenditure in Year 8: ",AV37}                           move cursor, prompt
          {RECALC AP8}{IF AP8=1}/CAW37~AV37~                                         get default
          {DOWN}{GETNUMBER "Expenditure in Year 9: ",AV38}                           move cursor, prompt
          {RECALC AP9}{IF AP9=1}/CAW38~AV38~                                         get default
          {DOWN}{GETNUMBER "Expenditure in Year 10: ",AV39}                          move cursor, prompt
          {RECALC AP10}{IF AP10=1}/CAW39~AV39~                                       get default
          {INDICATE}{WINDOWSOFF}/CAV30..AV39~AW30..AW39~{WINDOWSON}{WINDOWSOFF}      reset defaults
          {RETURN}                                                                   return to main macro
```

ROAD CONDITION INPUT METHOD CHOICE SUBROUTINE (called from main macro)

```
RCC       {GOTO}BE1~{DOWN 15}{RIGHT}{WINDOWSON}{INDICATE MENU}                       initialize screen
          {GETNUMBER "Please type the number of your choice: ",Z1}                   prompt
          {INDICATE}{WINDOWSOFF}                                                     screen update
          {IF Z1=1}{BRANCH RCM}                                                      program branch - miles
          {IF Z1=2}{BRANCH RCP}                                                      program branch - percent
          {BEEP 4}{BEEP 4}{BRANCH RCC}                                               on error, repeat subroutine rcc
```

ROAD CONDITIONS BY PERCENT SUBROUTINE - TOTAL MILES (branch from rcc)

```
RCP       {GOTO}AT61~{DOWN 11}{RIGHT 2}{WINDOWSON}{INDICATE INPUT}                   initialize screen
          {GETNUMBER "Total number of road miles? ",AV72}{RECALC AQ13}               prompt, test = 0
          {IF AQ13=1}{BEEP}{BEEP}                                                    error check
          {IF AQ13=1}{GETLABEL "YOU MUST HAVE MADE A MISTAKE. HIT RETURN TO TRY AGAIN ",AQ14}      error msg
          {IF AQ13=1}{WINDOWSOFF}{RCP}                                               on error - repeat subroutine rcp
          {IF AV72=0}{BEEP}{BEEP}                                                    error check
          {IF AV72=0}{GETLABEL "0 IS NOT ACCEPTED.  HIT RETURN TO TRY AGAIN ",AP15}  error msg
          {IF AV72=0}{WINDOWSOFF}{RCP}                                               on error - repeat subroutine rcp
          {DOWN 3}{RCP1}{RETURN}                                                     move cursor, branch to rcp1
```

ANNOTATED PROGRAM

ROAD CONDITIONS BY PERCENT SUBROUTINE (called from rcp)

```
RCP1            {INDICATE INPUT}                                                             set indicator
                {GETNUMBER "Percentage of total miles in excellent condition [in integer form]? ",AV75}   prompt
                {RECALC AP16}{IF AP16=1}/CZ11~AV76~                                          get default
                {RECALC AV80}{DOWN}                                                          recalc total, move cursor
                {GETNUMBER "Percentage of total miles in good condition [in integer form]? ",AV76}        prompt
                {RECALC AP17}{IF AP17=1}/CZ12~AV77~                                          get default
                {RECALC AV80}{DOWN}                                                          recalc total, move cursor
                {GETNUMBER "Percentage of total miles in fair condition [in integer form]? ",AV77}        prompt
                {RECALC AP18}{IF AP18=1}/CZ13~AV78~                                          get default
                {RECALC AV80}{DOWN}                                                          recalc total, move cursor
                {GETNUMBER "Percentage of total miles in poor condition [in integer form]? ",AV78}        prompt
                {RECALC AP19}{IF AP19=1}/CZ14~AV79~                                          get default
                {RECALC AV80}{INDICATE}{RECALCCOL AW75..AW80}                                recalc totals
                {WINDOWSOFF}{WINDOWSON}{WINDOWSOFF}                                          screen update
                {IF AV80<>100}{INDICATE ERROR}{BEEP}{BEEP}                                   error check
                {IF AV80<>100}{GETLABEL "DOES NOT TOTAL 100 PERCENT.  HIT RETURN TO TRY AGAIN ",AQ15}     error msg
                {IF AV80<>100}{UP 3}{WINDOWSON}{RCP1}                                        on error - repeat subroutine rcp1
                {RECALC AQ10}{IF AQ10=1}{INDICATE ERROR}{BEEP}{BEEP}                         error check
                {IF AQ10=1}{GETLABEL "DOES NOT TOTAL CORRECTLY.  HIT RETURN TO TRY AGAIN ",AQ15}          error msg
                {IF AQ10=1}{UP 3}{WINDOWSON}{RCP1}                                           on error - repeat subroutine rcp1
                /CAV76~Z11~/CAV77~Z12~/CAV78~Z13~/CAV79~Z14~                                 reset defaults
                {INDICATE}{RETURN}                                                           return to main macro
```

ROAD CONDITIONS BY MILES SUBROUTINE (branch from rcc)

```
RCM             {GOTO}AT41~{DOWN 13}{RIGHT 2}{WINDOWSON}{INDICATE INPUT}                     initialize screen
                {GETNUMBER "Number of road miles in excellent condition? ",AV54}             prompt
                {RECALC AP11}{IF AP11=1}/CZ11~AV54~                                          get default
                {RECALC AV59}{DOWN}                                                          recalc total, move cursor
                {GETNUMBER "Number of road miles in good condition? ",AV55}                  prompt
                {RECALC AP12}{IF AP12=1}/CZ12~AV55~                                          get default
                {RECALC AV59}{DOWN}                                                          recalc total, move cursor
                {GETNUMBER "Number of road miles in fair condition? ",AV56}                  prompt
                {RECALC AP13}{IF AP13=1}/CZ13~AV56~                                          get default
                {RECALC AV59}{DOWN}                                                          recalc total, move cursor
                {GETNUMBER "Number of road miles in poor condition? ",AV57}                  prompt
                {RECALC AP14}{IF AP14=1}/CZ14~AV57~                                          get default
                {RECALC AV59}{RECALCCOL AW54..AW59}                                          recalc total, calc percent
                {WINDOWSOFF}/CAV54~Z11~/CAV55~Z12~/CAV56~Z13~/CAV57~Z14~                     reset defaults
                {WINDOWSON}{INDICATE}                                                        screen update
                {WINDOWSOFF}{RETURN}                                                         return to main macro
```

ANNOTATED PROGRAM

REPAIR STRATEGY SELECTION SUBROUTINE (called from main macro)

```
STRAT    {GOTO}BE21~{DOWN 17}{RIGHT}{WINDOWSON}{INDICATE MENU}          initialize screen
         {GETNUMBER "Please type the number of your choice: ",Z2}       prompt
         {INDICATE}{WINDOWSOFF}                                         screen update
         {IF Z2<>1}{IF Z2<>2}{IF Z2<>3}{BEEP 4}{BEEP 4}{STRAT}           error check - repeat subroutine s
         {RETURN}                                                       return to main macro
```

GRAPH CREATION SUBROUTINE (called from main macro)

```
GRPH     {GOTO}BE81~{DOWN 9}{RIGHT}^WAIT A MOMENT PLEASE, I'M COMPUTING . . .~   initialize screen
         {WINDOWSON}{INDICATE COMP}{CALC}{WINDOWSOFF}                   initialize screen, recalc workshe
         /GRGTLXYEAR~OLAexc/good~LBfair~LCpoor~TFROAD CONDITIONS~        set graph X range, titles (rd con
         TXYEAR~TYMILES~                                                set axis titles
         TSPercentage-Based Strategy~QApeg~Bpf~Cpp~NCPRC~               set graph ranges, name graph
         OTS{ESC}Best-First Strategy~QAmeg~Bmf~Cmp~NCMRC~               set graph ranges, name graph
         OTS{ESC}Worst-First Strategy~QAreg~Brf~Crp~NCRRC~              set graph ranges, name graph
         RGTLXYEAR~OTFROAD MAINTENANCE BACKLOG~TYDOLLARS~TXYEAR~FALQ    set graph titles (backlog)
         TSPercentage-Based Strategy~QApbl~NCPBL~                       set graph ranges, name graph
         OTS{ESC}Best-First Strategy~QAmbl~NCMBL~                       set graph ranges, name graph
         OTS{ESC}Worst-First Strategy~QArbl~NCRBL~                      set graph ranges, name graph
         Q{INDICATE}{RETURN}                                            return to main macro
```

VIEW GRAPH SUBROUTINE (called from main macro)

```
VIEW     {IF Z2=1}/GNUPRC~NUPBL~Q                                       view named graph
         {IF Z2=2}/GNUMRC~NUMBL~Q                                       view named graph
         {IF Z2=3}/GNURRC~NURBL~Q                                       view named graph
         {INDICATE}{RETURN}                                             return to main macro
```

INPUT SUMMARY SUBROUTINE (called from options menu)

```
SUM      {WINDOWSOFF}{GOTO}BH1~{RECALC SUMMARY}{WINDOWSON}{WINDOWSOFF}  initialize screen
         /WGDOCNQ{INDICATE SUM}                                         turn off date display
         {INDICATE}/WGDOCSQ{RETURN}                                     turn on date display, return
```

PRINT REPORT SUBROUTINE (called from options menu)

```
PRNT     /PPCARASSUMP~OMR236~QAGCROMLO~MR240~H@||Page #~S\027\          print input summary, set prntr
         015                                                            compressed print setup string
         ~QQ                                                            quit print options
         {IF Z2=1}/PPRARP~GLLLLLLLLLLLLLLLCRRSUMP~GQ                    print report
         {IF Z2=2}/PPRARM~GLLLLLLLLLLLLLLLCRRSUMM~GQ                    print report
         {IF Z2=3}/PPRARR~GLLLLLLLLLLLLLLLCRRSUMR~GQ                    print report
         {RETURN}                                                       return to main macro
```

ANNOTATED PROGRAM

MAIN OPTIONS MENU SUBROUTINE

```
MBRANCH     {MENUBRANCH AT82}{MBRANCH}                                          branch program to main options me
```

GRAPH EDIT SUBROUTINE (called from graph menu)

```
GTITLE      {GOTO}BF65~^EDIT?~{GMENU}                                           insert EDIT on screen
            {MENUBRANCH AT116}{RETURN}                                          branch to graph menu
```

GRAPH SELECTION SUBROUTINE (called from gmenu)

```
GMENU       {GOTO}BE61~{DOWN 16}{RIGHT}{WINDOWSON}{INDICATE INPUT}              initialize screen
            {GETNUMBER "Please type the number of your choice: ",Z3}            prompt
            {INDICATE}{WINDOWSOFF}                                              screen update
            {IF Z3<>1}{IF Z3<>2}{IF Z3<>3}{BEEP 4}{BEEP 4}{GMENU}               error check
            {RETURN}                                                            return to main macro
```

MAIN TITLE EDITING SUBROUTINE (called from graph submenu)

```
MAIN        {PANELON}                                                           turn control panel on
            {IF Z2=1}{IF Z3<>2}/GNUPRC~OTFqw{ESC}{?}~QNCPRC~VQ                  view graph, edit main title
            {IF Z2=1}{IF Z3<>1}/GNUPBL~OTFqw{ESC}{?}~QNCPBL~VQ                  view graph, edit main title
            {IF Z2=2}{IF Z3<>2}/GNUMRC~OTFqw{ESC}{?}~QNCMRC~VQ                  view graph, edit main title
            {IF Z2=2}{IF Z3<>1}/GNUMBL~OTFqw{ESC}{?}~QNCMBL~VQ                  view graph, edit main title
            {IF Z2=3}{IF Z3<>2}/GNURRC~OTFqw{ESC}{?}~QNCRRC~VQ                  view graph, edit main title
            {IF Z2=3}{IF Z3<>1}/GNURBL~OTFqw{ESC}{?}~QNCRBL~VQ                  view graph, edit main title
            {PANELOFF}{RETURN}                                                  panel off, return
```

SUBTITLE EDITING SUBROUTINE (called from graph submenu)

```
SUB         {PANELON}                                                           turn control panel on
            {IF Z2=1}{IF Z3<>2}/GNUPRC~OTSqw{ESC}{?}~QNCPRC~VQ                  view graph, edit subtitle
            {IF Z2=1}{IF Z3<>1}/GNUPBL~OTSqw{ESC}{?}~QNCPBL~VQ                  view graph, edit subtitle
            {IF Z2=2}{IF Z3<>2}/GNUMRC~OTSqw{ESC}{?}~QNCMRC~VQ                  view graph, edit subtitle
            {IF Z2=2}{IF Z3<>1}/GNUMBL~OTSqw{ESC}{?}~QNCMBL~VQ                  view graph, edit subtitle
            {IF Z2=3}{IF Z3<>2}/GNURRC~OTSqw{ESC}{?}~QNCRRC~VQ                  view graph, edit subtitle
            {IF Z2=3}{IF Z3<>1}/GNURBL~OTSqw{ESC}{?}~QNCRBL~VQ                  view graph, edit subtitle
            {PANELOFF}{RETURN}                                                  panel off, return
```

ANNOTATED PROGRAM

GRAPH VIEWING SUBROUTINE (called from graph menu)

```
VGRAPH      {GOTO}BF65~^VIEW?~{GMENU}                                  insert VIEW on screen
            {IF Z2=1}{IF Z3<>2}/GNUPRC~Q                               view graph
            {IF Z2=1}{IF Z3<>1}/GNUPBL~Q                               view graph
            {IF Z2=2}{IF Z3<>2}/GNUMRC~Q                               view graph
            {IF Z2=2}{IF Z3<>1}/GNUMBL~Q                               view graph
            {IF Z2=3}{IF Z3<>2}/GNURRC~Q                               view graph
            {IF Z2=3}{IF Z3<>1}/GNURBL~Q                               view graph
            {menubranch at98}                                          branch program to graph menu
```

SAVE GRAPH SUBROUTINE (called from graph menu)

```
SGRAPH      {GOTO}BE101~{DOWN 18}{RIGHT}{WINDOWSON}{WINDOWSOFF}        initialize screen
            {GETLABEL " ",Z6}                                          prompt
            {GOTO}BF65~^SAVE?~{GMENU}{PANELON}                         insert SAVE on screen
            {IF Z2=1}{IF Z3<>2}/GNUPRC~SQW{ESC}{?}~RQQ{ESC}            view graph, save
            {IF Z2=1}{IF Z3<>1}/GNUPBL~SQW{ESC}{?}~RQQ{ESC}            view graph, save
            {IF Z2=2}{IF Z3<>2}/GNUMRC~SQW{ESC}{?}~RQQ{ESC}            view graph, save
            {IF Z2=2}{IF Z3<>1}/GNUMBL~SQW{ESC}{?}~RQQ{ESC}            view graph, save
            {IF Z2=3}{IF Z3<>2}/GNURRC~SQW{ESC}{?}~RQQ{ESC}            view graph, save
            {IF Z2=3}{IF Z3<>1}/GNURBL~SQW{ESC}{?}~RQQ{ESC}            view graph, save
            {PANELOFF}{RETURN}                                         return to main macro
```

RESULTS SUMMARY SUBROUTINE (called from main macro and options menu)

```
OUTPUT      {IF Z2=1}/RVAH7..AM17~BU7..BZ17~                           copy values to summary screen
            {IF Z2=2}/RVAH27..AM37~BU7..BZ17~                          copy values to summary screen
            {IF Z2=3}/RVAH47..AM57~BU7..BZ17~                          copy values to summary screen
            {GOTO}BU1~{WINDOWSON}{WINDOWSOFF}                          initialize screen
            {GETLABEL " ",Z6}                                          wait for ready
            {RETURN}                                                   return to main macro
```

ONERROR SUBROUTINE 1 (used if an error during execution)

```
OOPS        {BEEP}{PANELOFF}{WINDOWSOFF}{ONERROR OOPS2}{MBRANCH}       on error - branch options menu
```

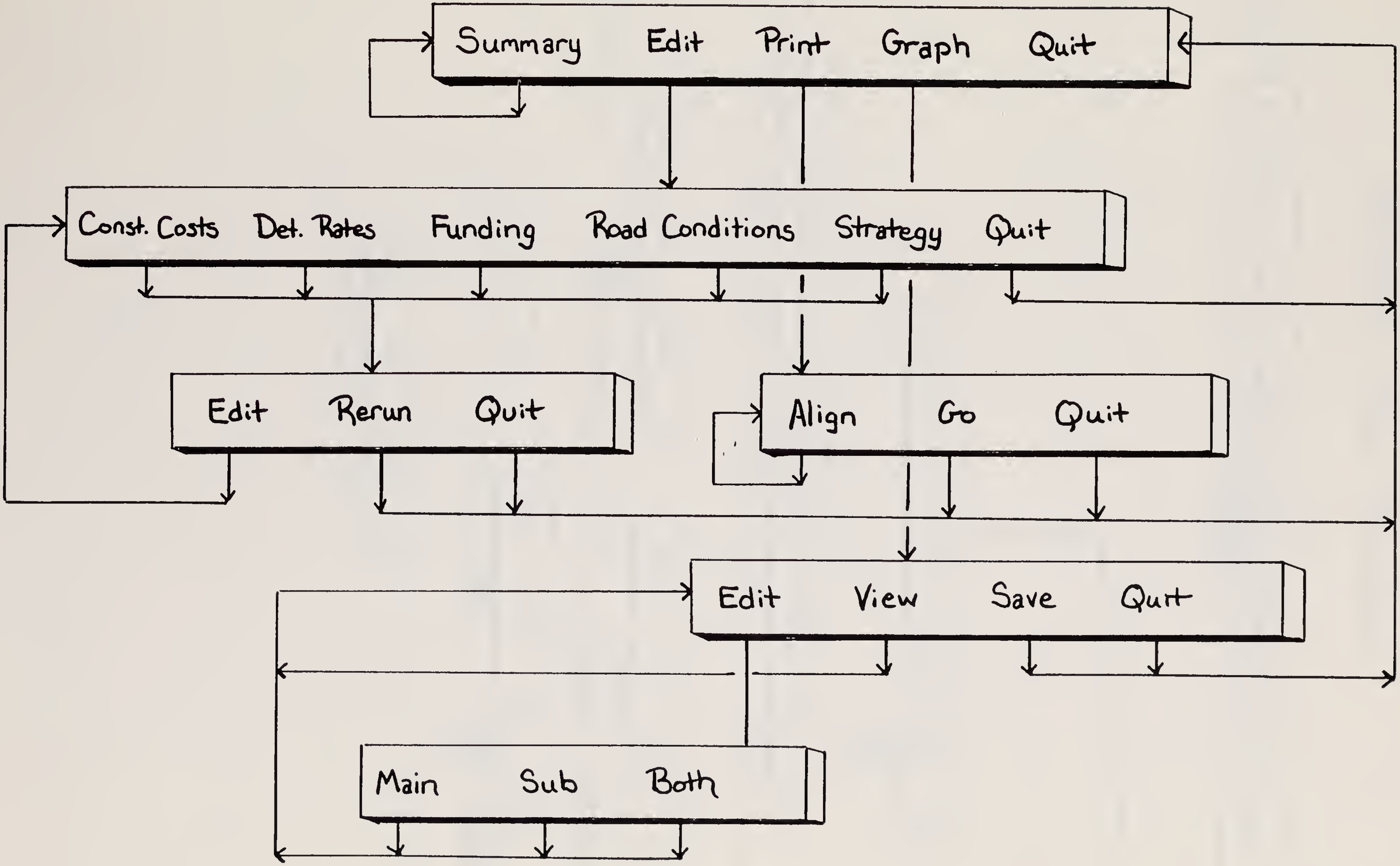
ONERROR SUBROUTINE 2 (used if an error during execution)

```
OOPS2       {BEEP}{PANELOFF}{WINDOWSOFF}{ONERROR OOPS}{MBRANCH}        on error - branch options menu
```

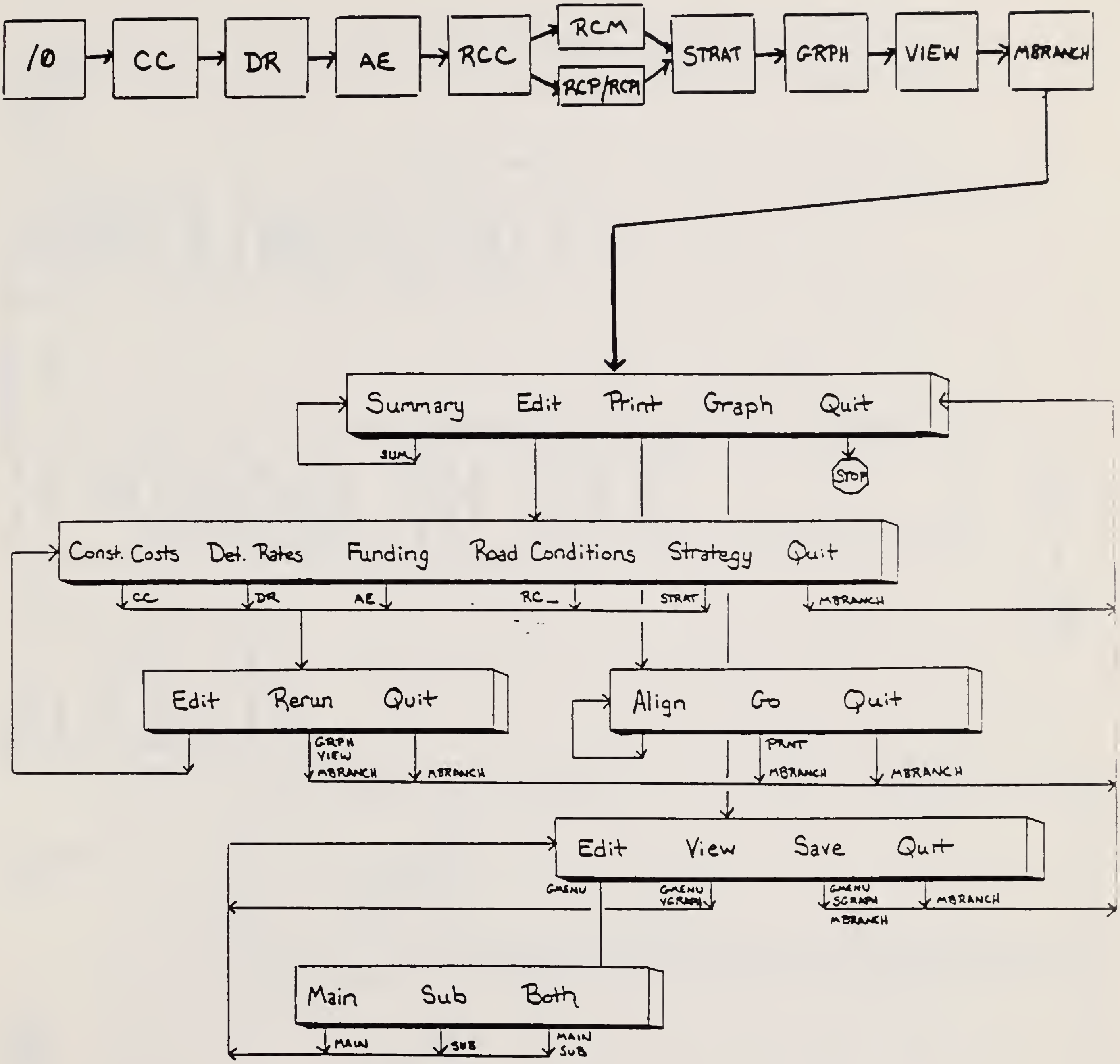
NAMED RANGES IN THE WORKSHEET

AE	subroutine	funding input
ARM	print output	annual results - best-first
ARP	print output	annual results - percent
ARR	print output	annual results - worst-first
ASSUMP	print output	summary of inputs
CC	subroutine	const. costs input
DR	subroutine	det. rates input
GMENU	subroutine	graph choice
GRPH	subroutine	graph creation
GTITLE	subroutine	graph editing
MAIN	subroutine	graph editing - main title
MBL	graph output	backlog - best-first
MBRANCH	subroutine	options menu
MEG	graph output	exc/good - best-first
MF	graph output	fair - best-first
MP	graph output	poor - best-first
OOPS	subroutine	error
OOPS2	subroutine	error
OUTPUT	subroutine	display result summary
PBL	graph output	backlog - percent
PEG	graph output	exc/good - percent
PF	graph output	fair - percent
PP	graph output	poor - percent
PRNT	subroutine	print report
RBL	graph output	backlog - worst-first
RCC	subroutine	road conditions input method choice
RCM	subroutine	road conditions input - miles
RCP	subroutine	road conditions input - percent
RCP1	subroutine	road conditions input - percent
REG	graph output	exc/good - worst-first
RF	graph output	fair - worst-first
RP	graph output	poor - worst-first
SGRAPH	subroutine	save graphs
STRAT	subroutine	strategy choice
SUB	subroutine	edit graph subtitles
SUM	subroutine	display input summary
SUMM	print output	results summary - best-first
SUMMARY	display output	input summary screen
SUMP	print output	result summary - percent
SUMR	print output	result summary - worst-first
VGRAPH	subroutine	view graphs
VIEW	subroutine	view graphs
YEAR	graph output	graph X range
\0	routine	main macro

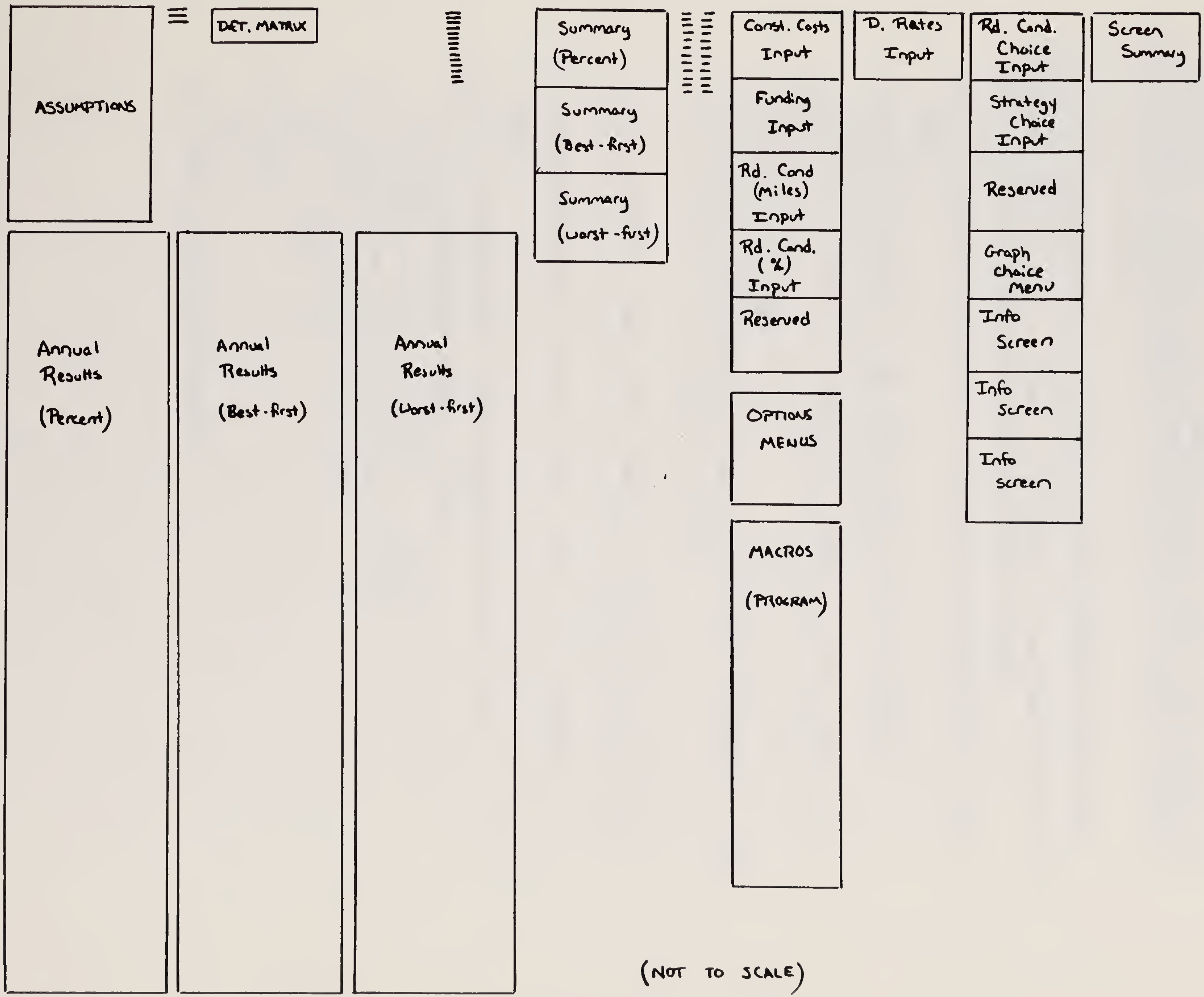
OPTIONS MENU DIAGRAM


Summary Edit Print Graph Quit
Const. Costs Det. Rates Funding Road Conditions Strategy Quit
Edit Rerun Quit
Align Go Quit
Edit View Save Quit
Main Sub Both

PROGRAM FLOW DIAGRAM



WORKSHEET LAYOUT



(NOT TO SCALE)

INSTALLATION

HARD-DISK SYSTEM

The program is based on the assumptions that Lotus 1-2-3, Release 2, is contained in a subdirectory named \123 on the hard disk (Drive C) and that the default directory of Lotus 1-2-3 is the main directory (C:\) of the hard-disk.

To check if your system is configured in this manner, follow these instructions:

NOTE: Instructions contained in brackets { } and underlined are for insertion of information particular to your system.

After booting the system up in DOS and at the prompt (C>), type

```
DIR/P  <-
```

Check the directory to see where Lotus 1-2-3 is located
(Look for key words like Lotus or 123)

If these key words are followed by "<DIR>", at the prompt (C>), type

```
cd {directory name}  <-
```

After finding files with names such as 123.EXE, 123.CMP, and other similar files, at the prompt (C>), type

```
cd <-
```

This returns the name of the directory that contains the Lotus files.

To check the default drive of Lotus, start 123 by typing

```
123 <-
```

while in the directory that contains the Lotus files.

After the spreadsheet appears, select

```
/ Worksheet   Global   Default   Directory
```

This returns the default directory of Lotus.

To leave, press RETURN, then select

```
Quit   / Quit  Yes
```

Then type

```
cd \ <-
```

to return to the main directory

To install the model for a system configured differently than stated above, follow these instructions:

Place the program disk in Drive A

Type

```
copy con a:defa  <-
copy a:auto123.wk1 {default drive}auto123.wk1  <-
c:  <-
cd {directory containing Lotus}  <-
123  <-
cd {default drive}  <-
del auto123.wk1  <-
cd {directory containing Lotus}  <-
lotus  <-
cd \ <-
```

Then strike F6, followed by return. At this point, type

```
A:MODEL  <-
```

to start the model.

PROGRAM ALTERATIONS

CAUTION: THE PROGRAM IS WRITTEN USING ADVANCED LOTUS MACRO COMMANDS. THE USER SHOULD BE FAMILIAR WITH THESE COMMANDS BEFORE ATTEMPTING TO ALTER THE PROGRAM IN ANY WAY. FOR DESCRIPTIONS AND INFORMATION ABOUT THESE COMMANDS, REFER TO THE LOTUS 1-2-3 MANUAL. ALSO, BEFORE MAKING ANY CHANGES TO THE PROGRAM, BACKUP THE WORKSHEET FILE BY COPYING IT INTO ANOTHER FILE.

To make any alterations to the program, you must first enter the Lotus 1-2-3 worksheet containing it. Since the program runs automatically upon the retrieval of the worksheet, follow these instructions:

Begin the model.

After the initial four screens, the program enters 123.

After the 123 logo and the quick worksheet display, strike

<CONTROL> BREAK

while the indicator in the upper right corner flashes WAIT

The computer beeps when the first screen is displayed [WAIT A MOMENT PLEASE] and the indicator flashes ERROR in the upper right corner.

At this point, strike

<CONTROL> BREAK

once more. You are now free to move around in the worksheet.

CAUTION: MOST OF THE CELLS IN THE WORKSHEET ARE PROTECTED AGAINST OVERWRITE. BEFORE MAKING ANY CHANGES, UNPROTECT THE CELLS BY SELECTING / Range Unprotect AND USING THE ARROW KEYS TO HIGHLIGHT THE REGION TO UNPROTECT AND PRESSING RETURN

PRINTER CONTROL CODE

To change the printer control code from compressed print to another choice, after entering the worksheet, hit F5 and type

```
AU292  <-
```

This line contains the printer setup string that selects compressed print To change this to another mode (see your printer manual for printer modes available), select

```
/ Range  Unprotect  <-
```

and type the appropriate decimal code, using three digits, followed by RETURN. (Example: The code for Italic Mode is 052)

Then, place the program disk in Drive A, hit F5 and type

```
BE121  <-
/  F  S  A:AUTO123  <-|
```

```
                          ANALYSIS OF MAINTENANCE
                        of Locally Maintained Roads
                   -------------------------------------------

==========  PAVEMENT MANAGEMENT FORECASTING MODEL OUTPUT  ==========

                 -------------  ASSUMPTIONS  -------------
                                -----------

1.  Construction Costs (per mile):

    surface treatment (improves good
      pavement to excellent condition                      $11,300
    rehabilitation (improves fair
      pavement to excellent condition                      $86,300
    reconstruction (improves poor
      pavement to excellent condition                     $259,900


2.  Deterioration Rates:

    excellent pavement becomes good in  10  years
         good pavement becomes fair in   5  years
         fair pavement becomes poor in   2  years


3.  Annual Expenditures:

    year 1                   $112,770,000
    year 2                   $112,770,000
    year 3                   $112,770,000
    year 4                   $112,770,000
    year 5                   $112,770,000
    year 6                   $112,770,000
    year 7                   $112,770,000
    year 8                   $112,770,000
    year 9                   $112,770,000
    year 10                  $112,770,000


4.  Current Road Conditions:
                                                         miles    % of total
    excellent condition                                2456.00      26.9
    good condition                                     2586.00      28.3
    fair condition                                     2812.00      30.8
    poor condition                                     1286.00      14.1
    ------------------------------------------------------------  --------
    total
                                                       9140.00     100.0
    --------------------------------------------------------------------
    BACKLOG (one-time expense needed to          $606,128,500
        make all roads excellent now)
```

```
----------------------------------------------------- ANNUAL RESULTS -----------------------------------------------------------------

e following analysis is based on the assumptions (above); works with 1986 dollars and does not account for inflation.
                                         Percentage-Based Approach

EAR 1:
-----
 the following work plan is completed:

                                              miles
  surface treatment (good-exc)               481.12
  rehabilitation (fair-exc)                  523.17
  reconstruction (poor-exc)                  239.26
  ---------------------------------------------------
  Total $ spent on work plan:          $112,770,000

YEAR 1:
------
The community will then have these road conditions:
                                                                  %
                                            miles   % total  at start
   excellent                              3453.96      37.8      26.9
   good                                   1929.50      21.1      28.3
   fair                                   1565.39      17.1      30.8
   poor                                   2191.15      24.0      14.1
   -------------------------------------- --------  --------
   Total                                  9140.00     100.0     100.0

Backlog                     $726,377,542
   (Total $ needed to make all roads excellent)

EAR 2:
-----
 the following work plan is completed:

                                              miles
  surface treatment (good-exc)               299.55
  rehabilitation (fair-exc)                  243.03
  reconstruction (poor-exc)                  340.18
  ---------------------------------------------------
  Total $ spent on work plan:          $112,770,000

YEAR 2:
------
The community will then have these road conditions:
                                                                  %
                                            miles   % total  at start
   excellent                              3991.32      43.7      26.9
   good                                   1649.35      18.0      28.3
   fair                                    987.17      10.8      30.8
   poor                                   2512.16      27.5      14.1
   -------------------------------------- --------  --------
   Total                                  9140.00     100.0     100.0

Backlog                     $756,740,810
   (Total $ needed to make all roads excellent)

EAR 3:
-----
 the following work plan is completed:

                                              miles
  surface treatment (good-exc)               245.79
  rehabilitation (fair-exc)                  147.11
  reconstruction (poor-exc)                  374.36
  ---------------------------------------------------
  Total $ spent on work plan:          $112,770,000

YEAR 3:
------
The community will then have these road conditions:
                                                                  %
                                            miles   % total  at start
   excellent                              4359.45      47.7      26.9
   good                                   1521.98      16.7      28.3
   fair                                    700.74       7.7      30.8
   poor                                   2557.83      28.0      14.1
   -------------------------------------- --------  --------
   Total                                  9140.00     100.0     100.0

Backlog                     $742,451,242
   (Total $ needed to make all roads excellent)
```

```
EAR 4:
-----
 the following work plan is completed:

                                                   miles
 surface treatment (good-exc)                     231.17
 rehabilitation (fair-exc)                        106.44
 reconstruction (poor-exc)                        388.50
 ---------------------------------------------------------
 Total $ spent on work plan:                $112,770,000
```

```
YEAR 4:
------
The community will then have these road conditions:

                                                              %
                                          miles   % total  at start
   excellent                            4649.61      50.9      26.9
   good                                 1468.59      16.1      28.3
   fair                                  555.32       6.1      30.8
   poor                                 2466.48      27.0      14.1
   ----------------------------------------------  --------  --------
   Total                                9140.00     100.0     100.0


Backlog                          $705,556,198
   (Total $ needed to make all roads excellent)
```

```
EAR 5:
-----
 the following work plan is completed:

                                                   miles
 surface treatment (good-exc)                     234.73
 rehabilitation (fair-exc)                         88.76
 reconstruction (poor-exc)                        394.22
 ---------------------------------------------------------
 Total $ spent on work plan:                $112,770,000
```

```
YEAR 5:
------
The community will then have these road conditions:

                                                              %
                                          miles   % total  at start
   excellent                            4902.36      53.6      26.9
   good                                 1452.05      15.9      28.3
   fair                                  480.05       5.3      30.8
   poor                                 2305.54      25.2      14.1
   ----------------------------------------------  --------  --------
   Total                                9140.00     100.0     100.0


Backlog                          $657,045,640
   (Total $ needed to make all roads excellent)
```

```
EAR 6:
-----
 the following work plan is completed:

                                                   miles
 surface treatment (good-exc)                     249.22
 rehabilitation (fair-exc)                         82.39
 reconstruction (poor-exc)                        395.70
 ---------------------------------------------------------
 Total $ spent on work plan:                $112,770,000
```

```
YEAR 6:
------
The community will then have these road conditions:

                                                              %
                                          miles   % total  at start
   excellent                            5139.44      56.2      26.9
   good                                 1452.50      15.9      28.3
   fair                                  439.40       4.8      30.8
   poor                                 2108.66      23.1      14.1
   ----------------------------------------------  --------  --------
   Total                                9140.00     100.0     100.0


Backlog                          $602,374,736
   (Total $ needed to make all roads excellent)
```

```
EAR 7:
-----
 the following work plan is completed:


                                                    miles
  surface treatment (good-exc)                     271.92
  rehabilitation (fair-exc)                         82.26
  reconstruction (poor-exc)                        394.76
  -------------------------------------------------------
  Total $ spent on work plan:                $112,770,000


EAR 8:
-----
 the following work plan is completed:


                                                    miles
  surface treatment (good-exc)                     302.26
  rehabilitation (fair-exc)                         85.94
  reconstruction (poor-exc)                        392.22
  -------------------------------------------------------
  Total $ spent on work plan:                $112,770,000


EAR 9:
-----
 the following work plan is completed:


                                                    miles
  surface treatment (good-exc)                     341.22
  rehabilitation (fair-exc)                         92.31
  reconstruction (poor-exc)                        388.41
  -------------------------------------------------------
  Total $ spent on work plan:                $112,770,000
```

```
YEAR 7:
------
The community will then have these road conditions:
                                                              %
                                        miles   % total  at start
   excellent                          5374.43      58.8      26.9
   good                               1458.41      16.0      28.7
   fair                                414.69       4.5      30.3
   poor                               1892.47      20.7      14.1
   ----------------------------------------  --------  --------
   Total                              9140.00     100.0     100.0


Backlog                          $544,120,586
   (Total $ needed to make all roads excellent)


YEAR 8:
------
The_community will then have these road conditions:
                                                              %
                                        miles   % total  at start
   excellent                          5617.41      61.5      26.9
   good                               1462.36      16.0      28.7
   fair                                395.60       4.3      30.3
   poor                               1664.62      18.2      14.1
   ----------------------------------------  --------  --------
   Total                              9140.00     100.0     100.0


Backlog                          $483,300,306
   (Total $ needed to make all roads excellent)


YEAR 9:
------
The community will then have these road conditions:
                                                              %
                                        miles   % total  at start
   excellent                          5877.61      64.3      26.9
   good                               1458.66      16.0      28.7
   fair                                375.88       4.1      30.3
   poor                               1427.36      15.6      14.1
   ----------------------------------------  --------  --------
   Total                              9140.00     100.0     100.0


Backlog                          $420,021,614
   (Total $ needed to make all roads excellent)
```

EAR 10:

------

the following work plan is completed:

	miles
surface treatment (good-exc)	391.63
rehabilitation (fair-exc)	100.92
reconstruction (poor-exc)	383.36
Total $ spent on work plan:	$112,770,000

YEAR 10:

The community will then have these road conditions:

	miles	% total	% at start
excellent	6165.75	67.5	26.9
good	1441.38	15.8	28.3
fair	350.89	3.8	30.8
poor	1181.98	12.9	14.1
Total	9140.00	100.0	100.0

Backlog $353,765,164
(Total $ needed to make all roads excellent)

== SUMMARY ============================

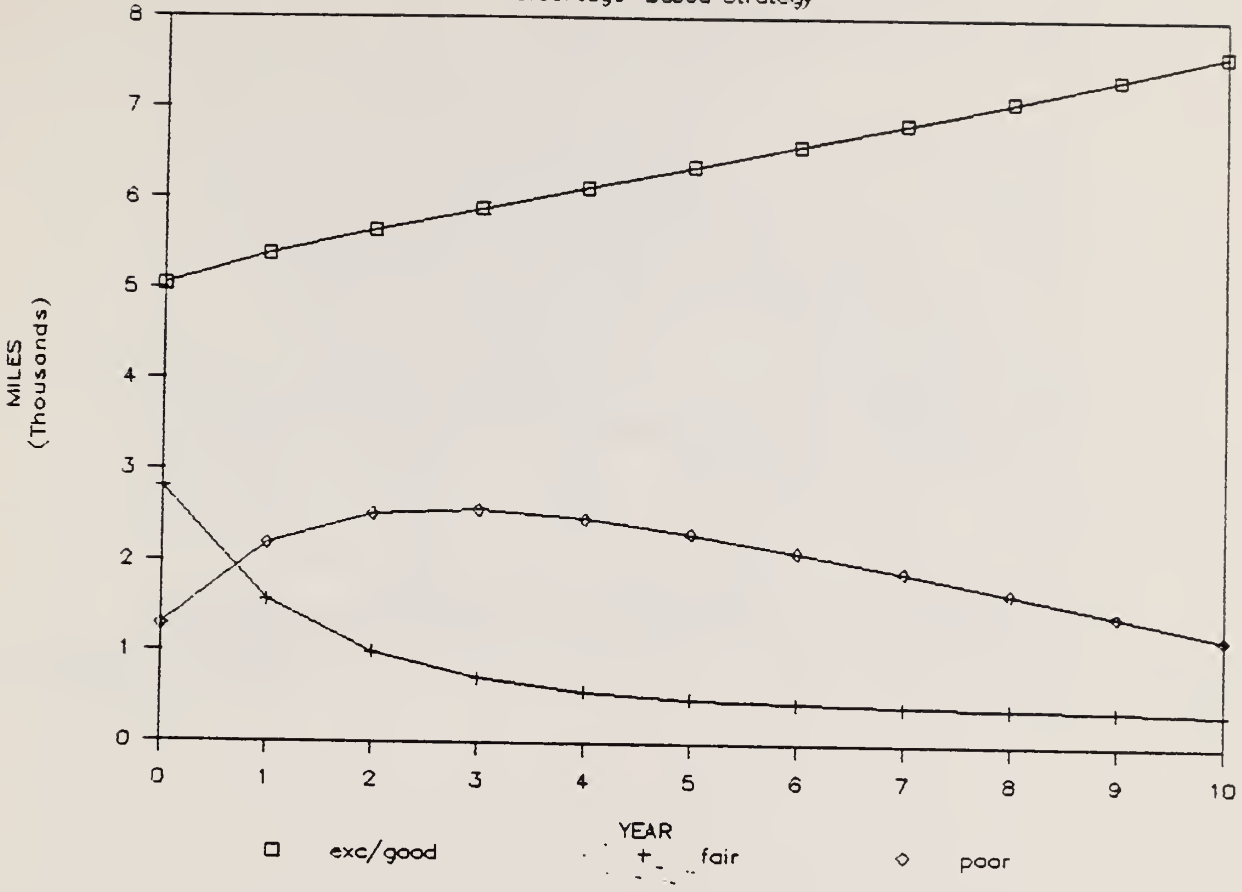
Percentage-Based Approach

YEAR	exc/good	fair	poor	total	Backlog *
	ROAD CONDITIONS				
0	5042.00	2812.00	1286.00	9140.00	$606,128,800
1	5383.46	1565.39	2191.15	9140.00	$726,377,542
2	5640.67	987.17	2512.16	9140.00	$756,740,810
3	5881.43	700.74	2557.83	9140.00	$742,451,842
4	6118.21	555.32	2466.48	9140.00	$705,556,198
5	6354.41	480.05	2305.54	9140.00	$657,045,640
6	6591.94	439.40	2108.66	9140.00	$602,374,786
7	6832.84	414.69	1892.47	9140.00	$544,120,686
8	7079.78	395.60	1664.62	9140.00	$483,300,306
9	7336.26	375.88	1427.86	9140.00	$420,021,614
10	7607.14	350.89	1181.98	9140.00	$353,765,164

* One-time expense which would be required to make all roads excellent.

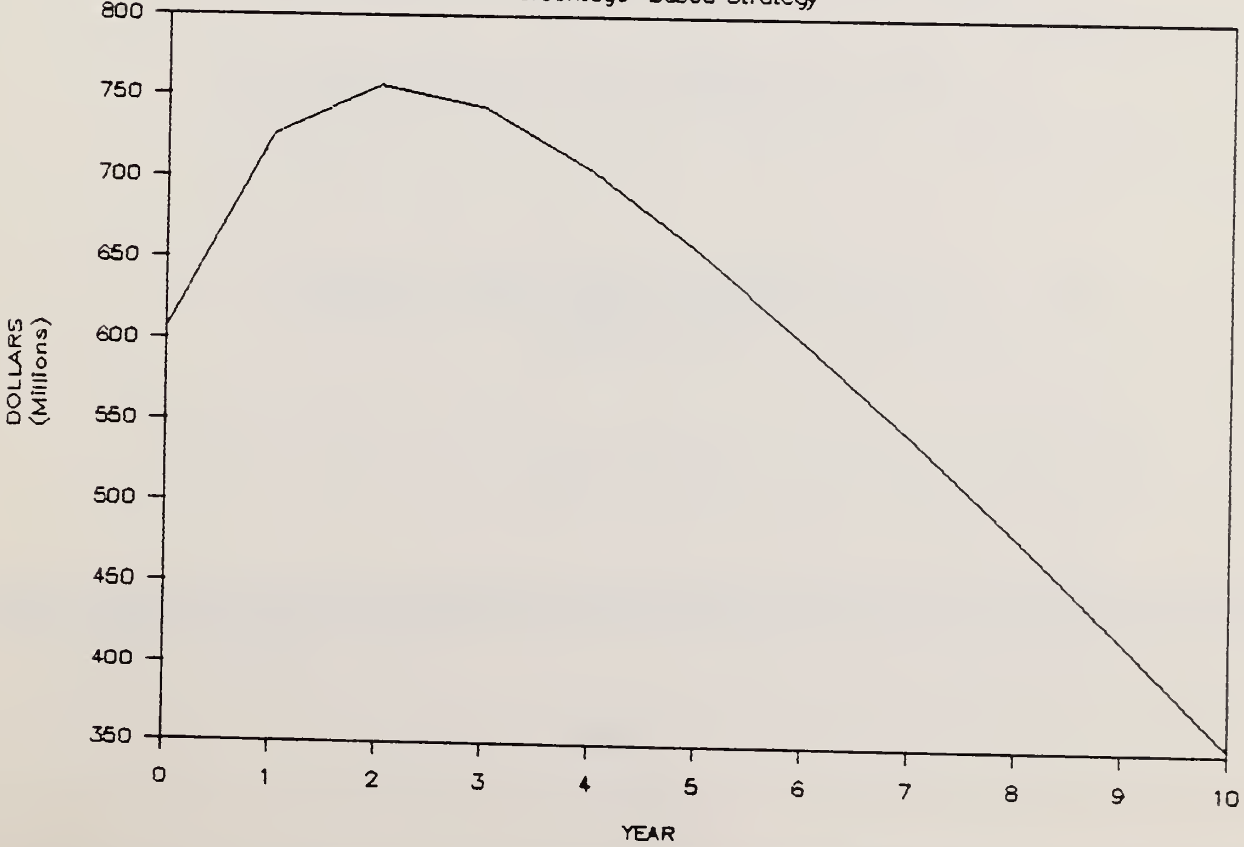
ROAD CONDITIONS

Percentage—Based Strategy



ROAD MAINTENANCE BACKLOG

Percentage—Based Strategy

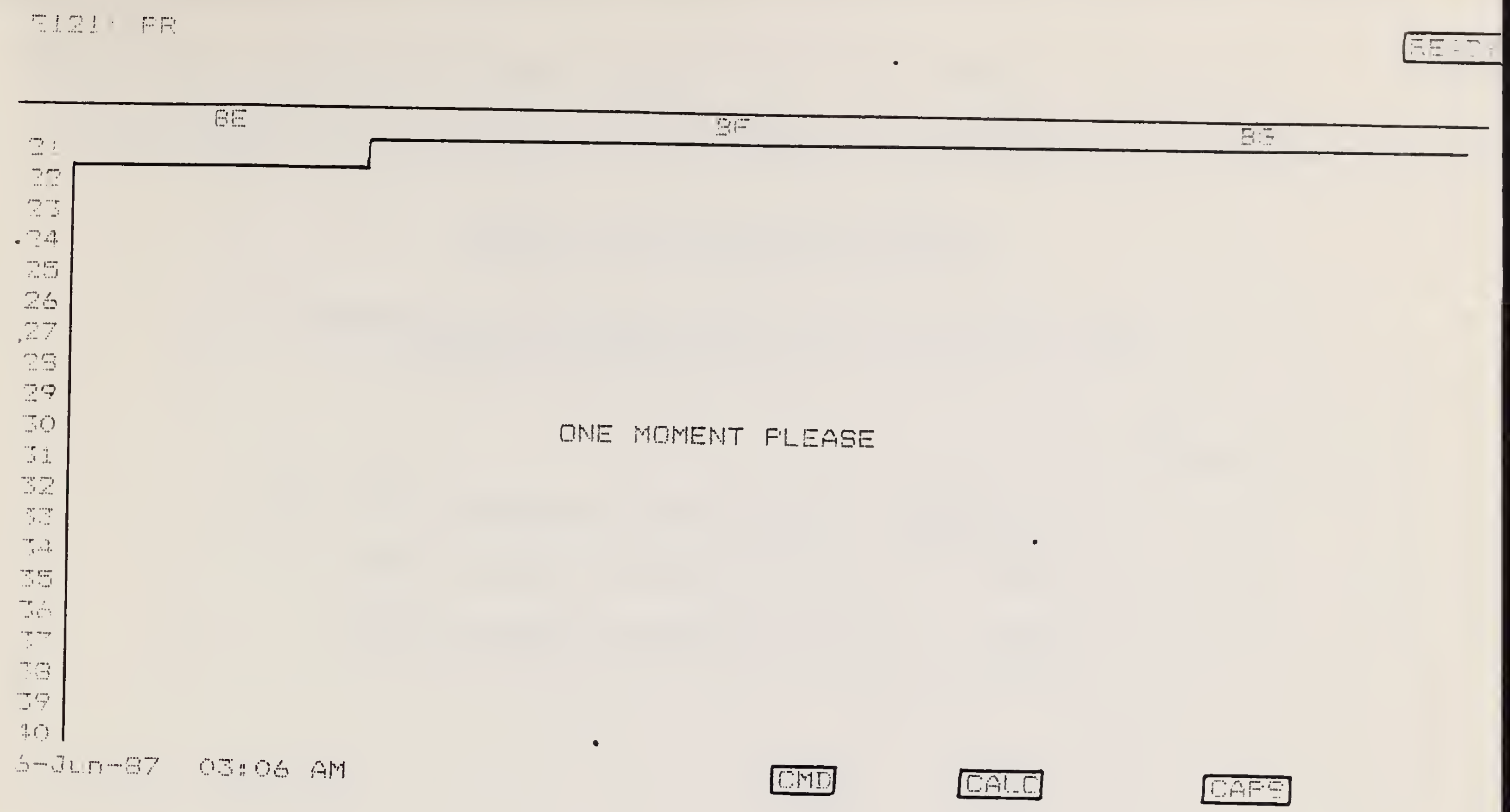


```
IMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM;
:..............................xXXx---------;
:...........................xXXXXXXX--xx----;
:.........................x.XXXXXXXXxxXXX---;
:...................xxxxXXXXXXXXXXXXXXX-----;
:....xXx...xxx.....XXXXXXXXXXXXX------------;
:....XXXXXXXXXXXXXXXXXXXXXXXXXXXX-----------;
:xxxXXXXXXXXXXXXXXXXXXXXXXXXX---------------;
:XXXXXXXXXXXXXXXXXXXXXXXXXXX----------------;
:..XXXXXXXXXXXXXXXXXXXXXXXX-----------------;
:...XXXXXXXXXXXXXXXXXXXXXXXx----x-----------;
:....XXXXXXXXXXXXXXXXXXXXXXXxxxxXXxxx-------;
:...XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX------;
:.....XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXx----;
:......XXXXXXXXXXXXXXXXXXXX....XXXXXXXXXXx--;
:.......XXXXXXXXXXXXXXXX.........XXXXXXXXX--;
:.......XXXXXXXXXXXXX..............XXXXX----;
LMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM?
:  XXX     XXX     XXX    XXX===Xx  xX==Xx  ;
:   X X   / XX     / X     XX   XX xX    X  ;
:   X  X /  XX    /===X    XX===X  XX       ;
:   X   X   XX   /     X   XX      xX    x  ;
:  XXX     XXXX XX     XX XXXX      xX==X   ;
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM<
trike a key when ready . . .
```

```
IMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM;
:                                                                 ;
:              PAVEMENT MANAGEMENT FORECASTING MODEL              ;
:          ---------------------------------------------          ;
:                                                                 ;
:                  An Analysis of Funding for the                 ;
:             Maintenance of Locally-Maintained Roads             ;
:                                                                 ;
:                                                                 ;
:                                                                 ;
:                                                                 ;
:                         Developed by the                        ;
:                METROPOLITAN AREA PLANNING COUNCIL               ;
:                           Boston, MA                            ;
:                                                                 ;
:                                                                 ;
:                                                                 ;
:                           June 1987                             ;
:                                                                 ;
:                                                                 ;
:                                                                 ;
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM<
trike a key when ready . . .
```

```
IMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM;
:                                                                             :
:                                                                             :
:      WELCOME TO THE PAVEMENT MANAGEMENT FORECASTING MODEL                   :
:                                                                             :
:                                                                             :
:         This model was developed to estimate the needed                    :
:         funds for the maintenance of locally-maintained                    :
:         roads by simulating the contest between pavement                    :
:         deterioration and roadway maintenance procedures.                   :
:                                                                             :
:                                                                             :
:     The model produces 10-year forecasts of road conditions                 :
:      and calculates the maintenance backlog of the network.                 :
:      It returns summaries of both the input and output, as                  :
:        well as yearly results, including road conditions,                   :
:       maintenance backlog, and annual work plan.  It also                   :
:        returns graphs of road conditions and maintenance                    :
:                  backlog over the 10-year period.                           :
:                                                                             :
:                                                                             :
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM<
trike a key when ready . . .
```

```
IMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM;
:                                                                             :
:                                                                             :
:       The model requires input of the following information:                :
:                                                                             :
:             Road Maintenance and Construction Unit Costs                    :
:             Pavement Deterioration Rates                                    :
:             Estimated Future Funding for Roadway Improvements               :
:             Current Road Conditions                                         :
:                                                                             :
:                                                                             :
:         Also to be selected is a roadway repair strategy                    :
:            from three different possible strategies.                        :
:                                                                             :
:                                                                             :
:        Default values based on best estimates from various                  :
:          expert sources are included in the model for the                   :
:         data on construction costs and deterioration rates.                 :
:                                                                             :
:                                                                             :
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM<
trike a key when ready . . .
```



```
5121: PR

21
22
23
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30                 ONE MOMENT PLEASE
31
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6-Jun-87  03:06 AM
```
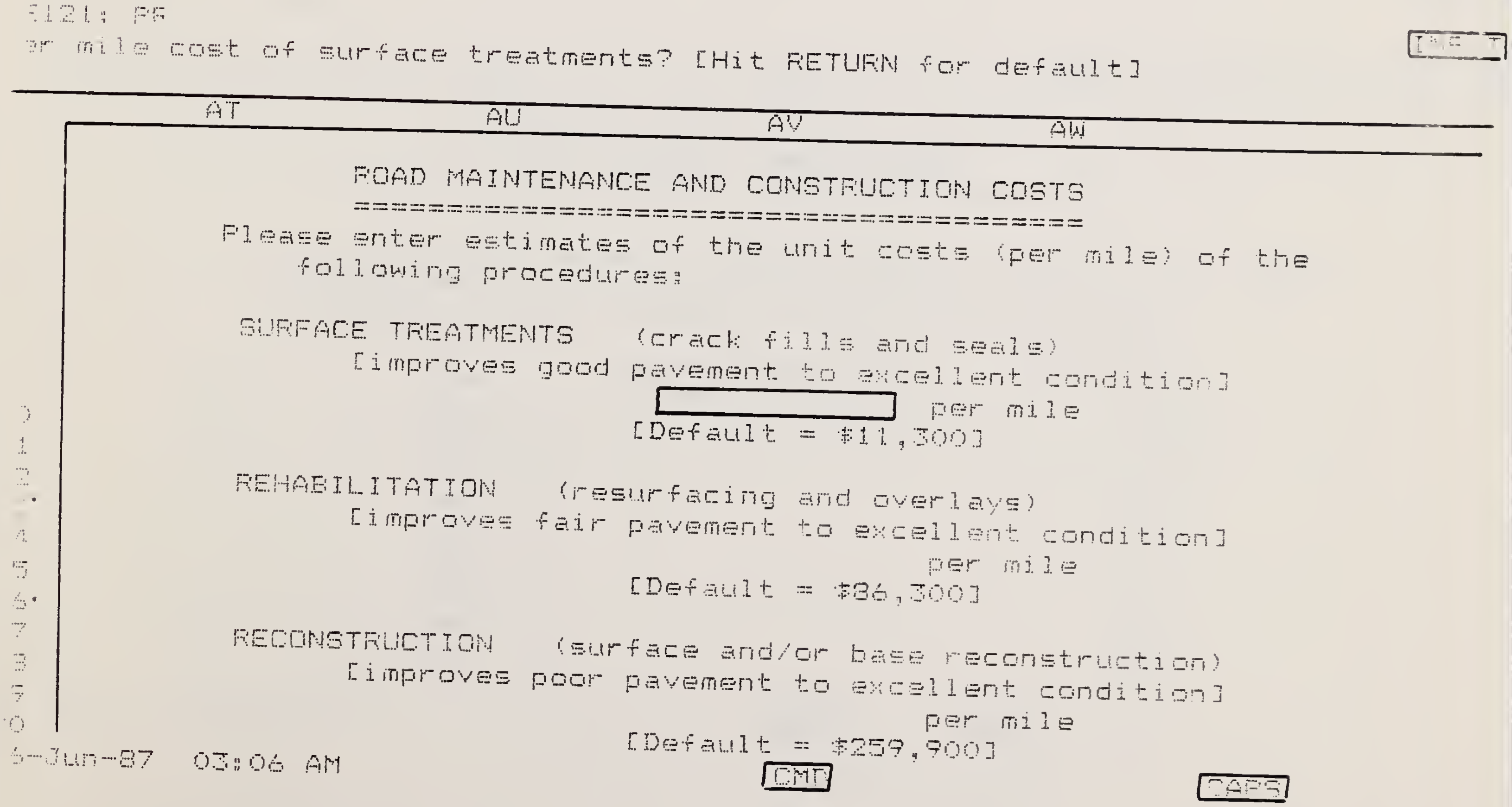
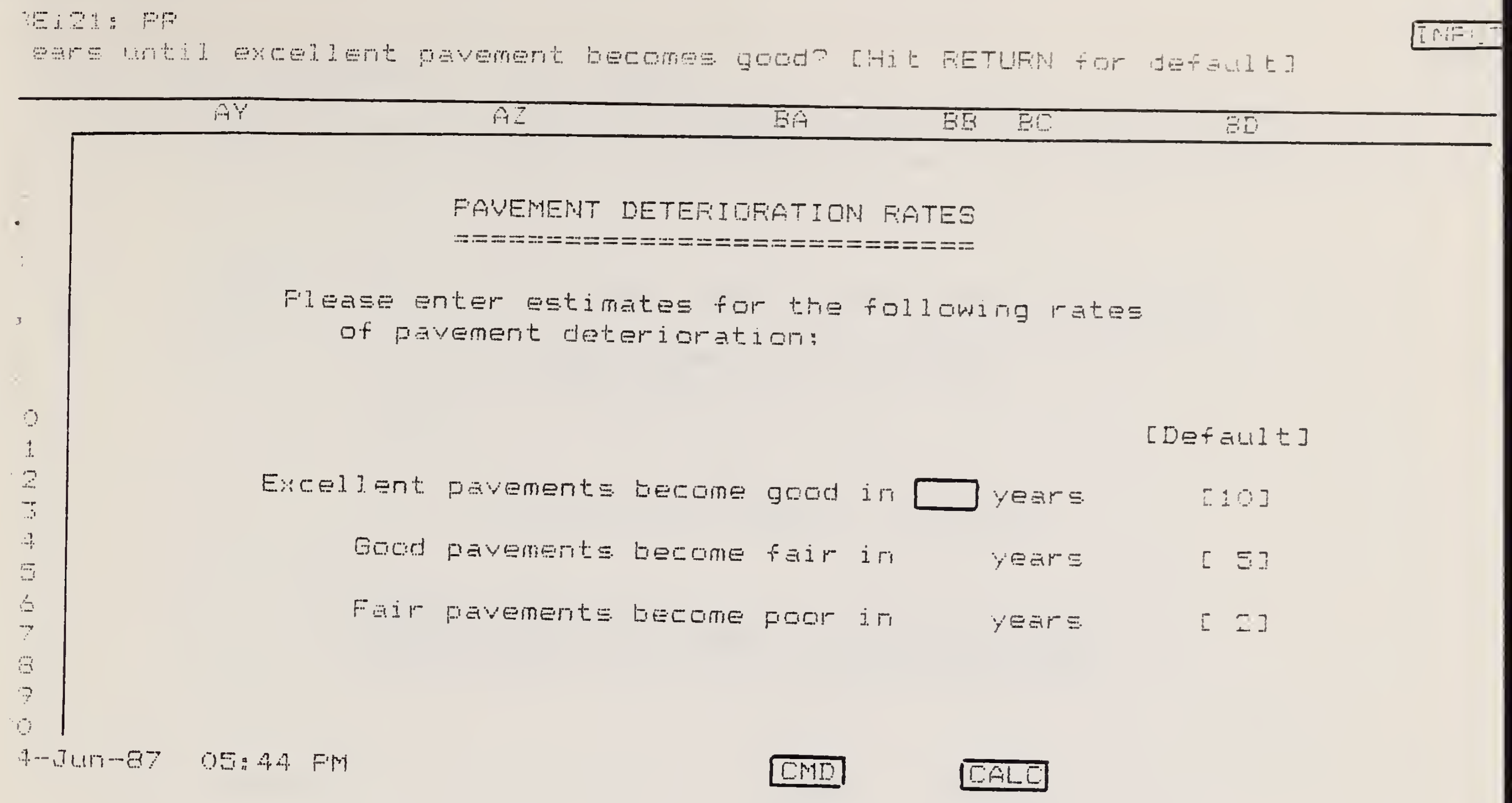
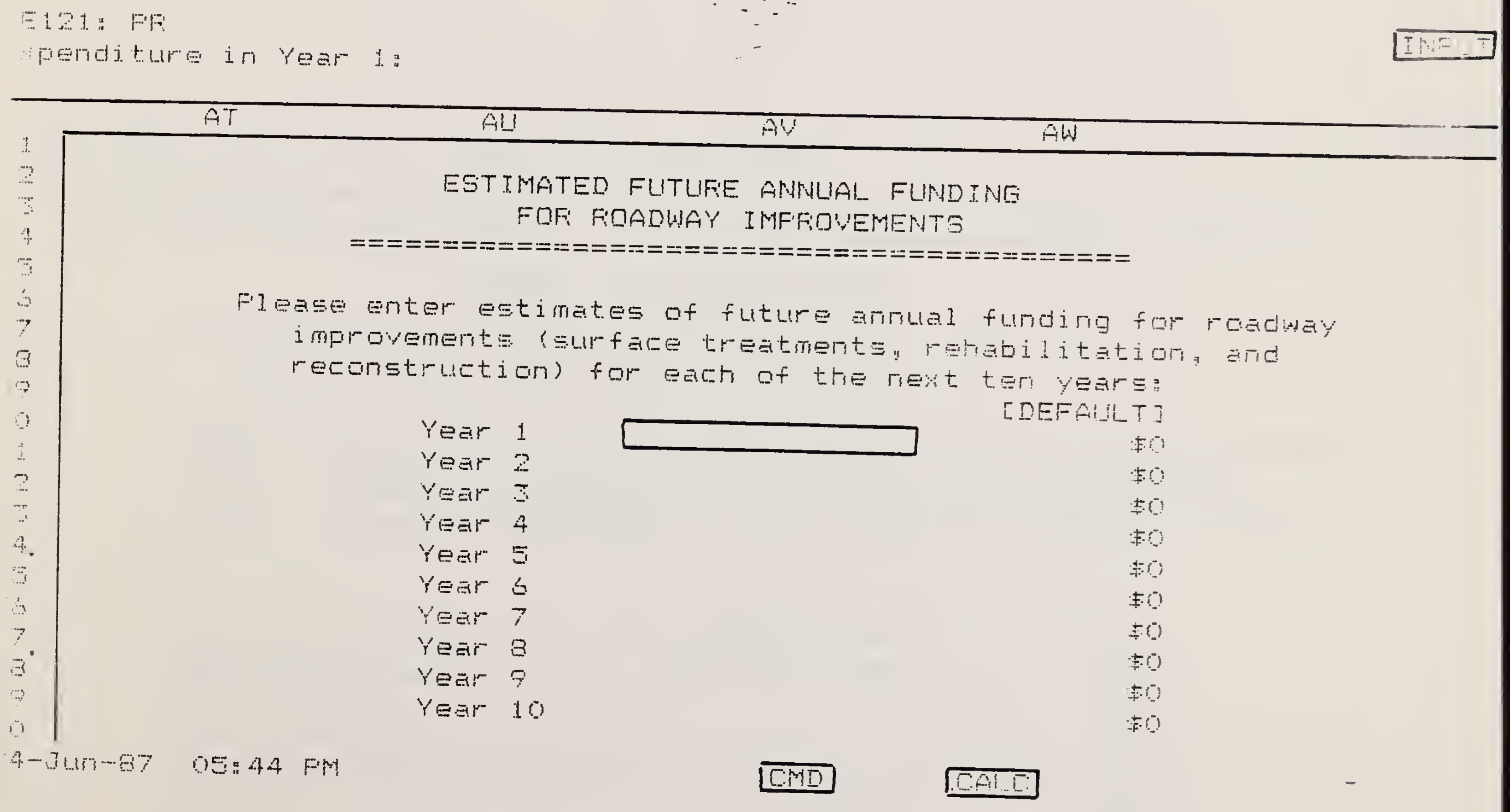



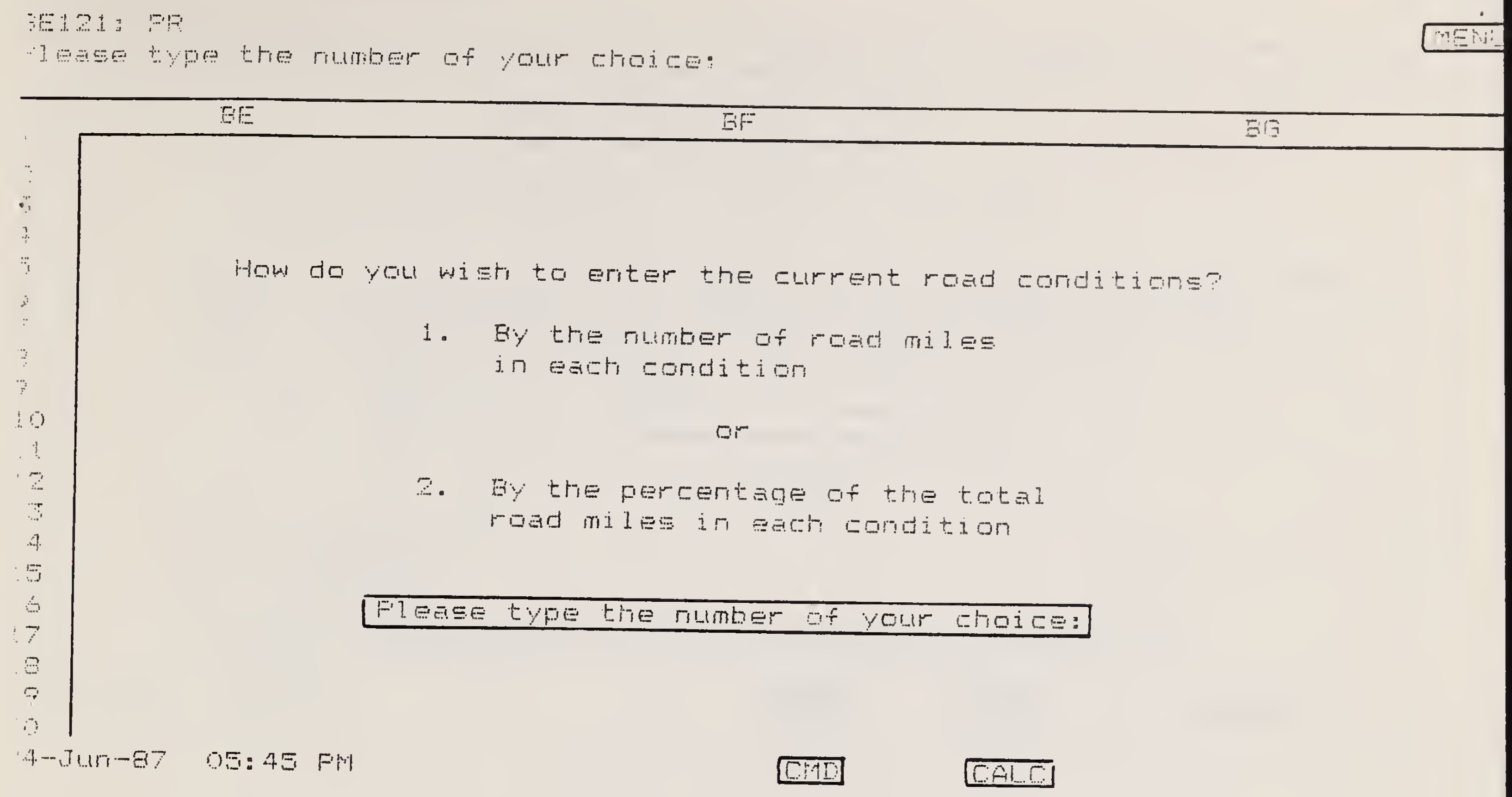
```
5121: PR
er mile cost of surface treatments? [Hit RETURN for default]

          ROAD MAINTENANCE AND CONSTRUCTION COSTS
          =======================================
      Please enter estimates of the unit costs (per mile) of the
        following procedures:

       SURFACE TREATMENTS   (crack fills and seals)
            [improves good pavement to excellent condition]
                                              per mile
                               [Default = $11,300]

       REHABILITATION   (resurfacing and overlays)
            [improves fair pavement to excellent condition]
                                              per mile
                               [Default = $86,300]

       RECONSTRUCTION   (surface and/or base reconstruction)
            [improves poor pavement to excellent condition]
                                              per mile
                               [Default = $259,900]
6-Jun-87  03:06 AM
```



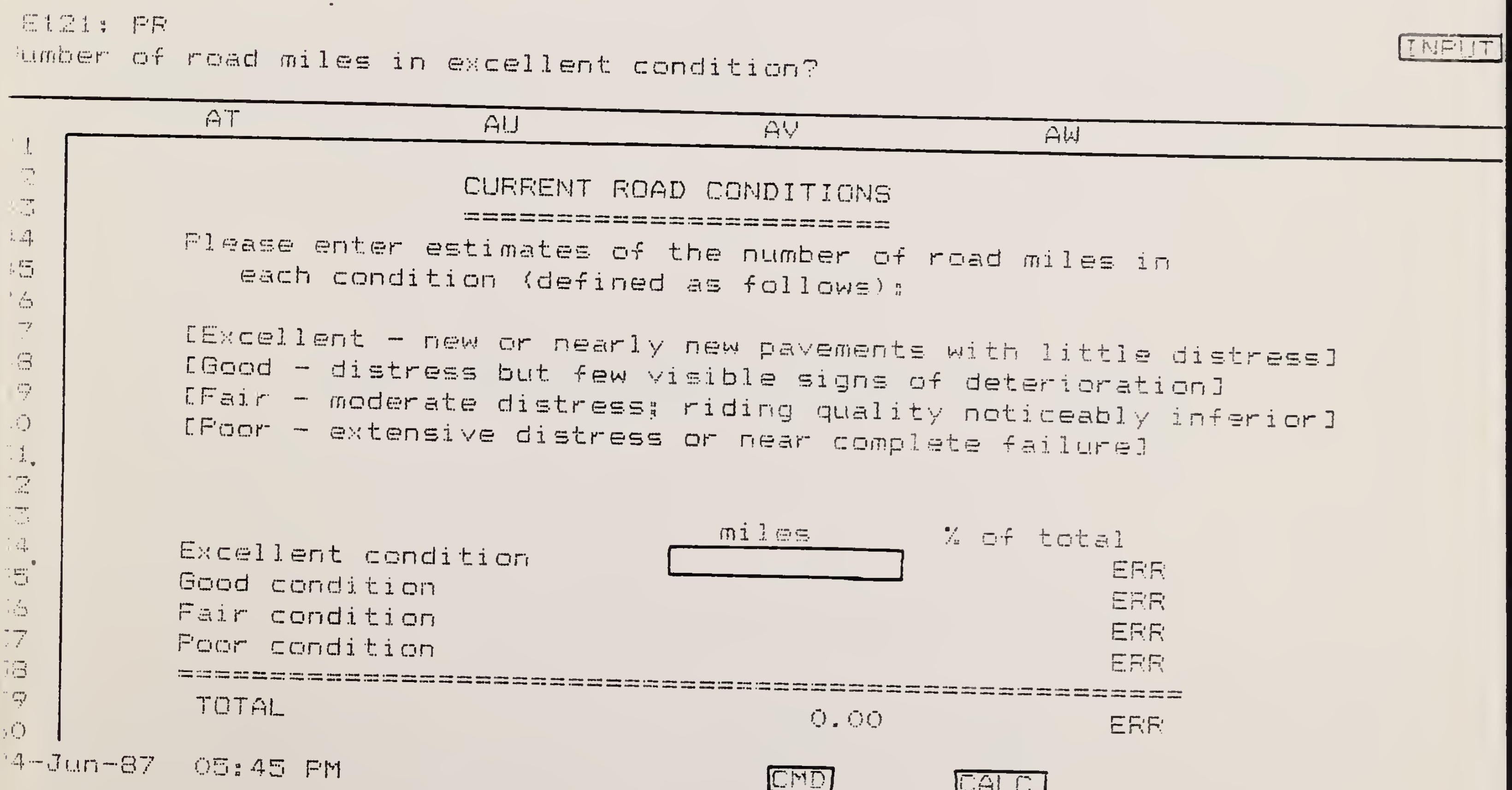
```
E121: PR                                                                   INPUT
ears until excellent pavement becomes good? [Hit RETURN for default]
          AY             AZ             BA        BB  BC         BD

                        PAVEMENT DETERIORATION RATES
                        ============================

                Please enter estimates for the following rates
                   of pavement deterioration:

                                                                [Default]
              Excellent pavements become good in [  ] years       [10]
                   Good pavements become fair in      years       [ 5]
                   Fair pavements become poor in      years       [ 2]

4-Jun-87   05:44 PM                      CMD        CALC
```



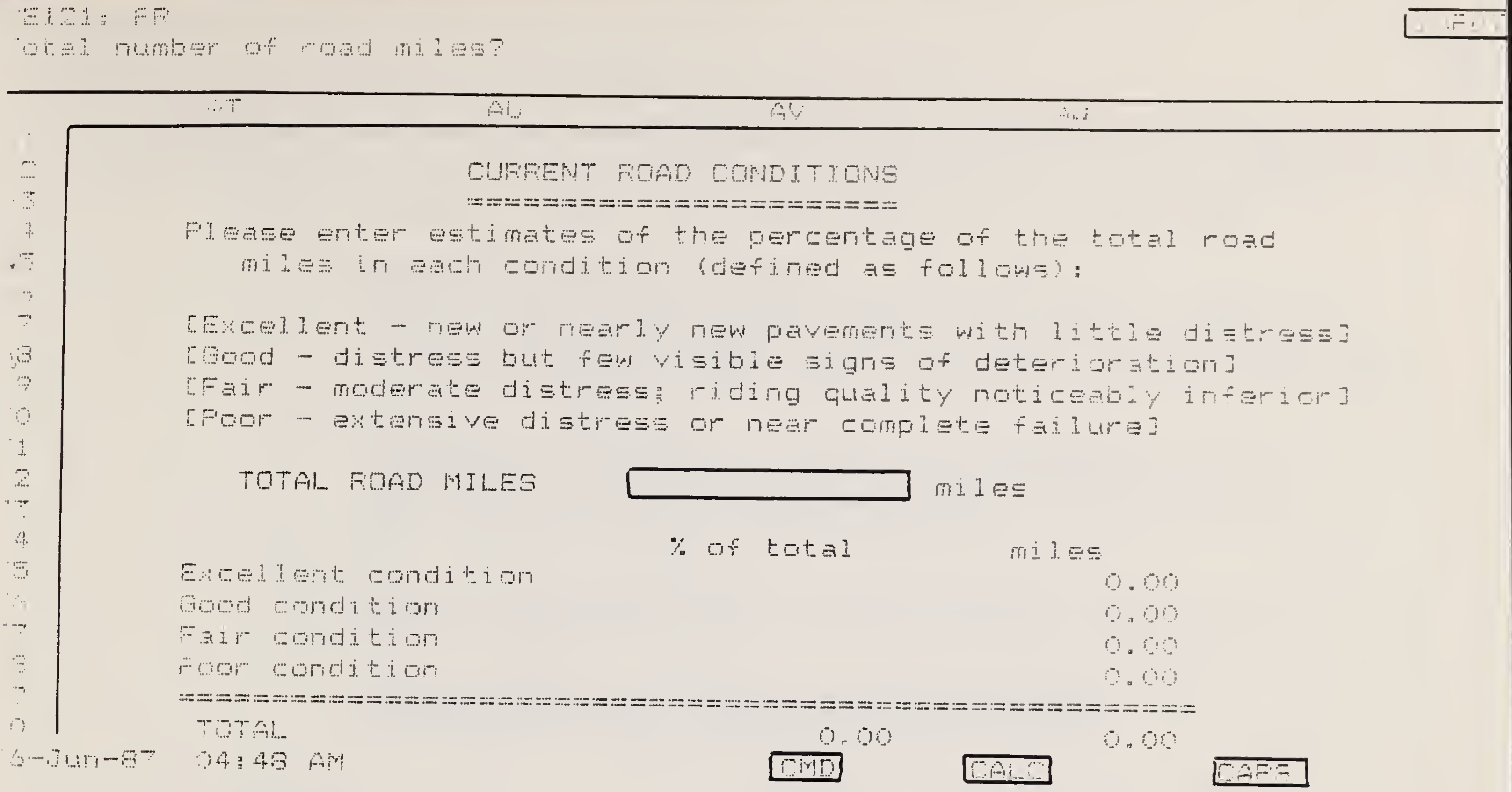
```
E121: PR                                                                   INPUT
penditure in Year 1:
          AT             AU             AV             AW

                         ESTIMATED FUTURE ANNUAL FUNDING
                            FOR ROADWAY IMPROVEMENTS
                    ==========================================

           Please enter estimates of future annual funding for roadway
              improvements (surface treatments, rehabilitation, and
              reconstruction) for each of the next ten years:
                                                       [DEFAULT]
                   Year 1      [                ]             $0
                   Year 2                                     $0
                   Year 3                                     $0
                   Year 4                                     $0
                   Year 5                                     $0
                   Year 6                                     $0
                   Year 7                                     $0
                   Year 8                                     $0
                   Year 9                                     $0
                   Year 10                                    $0

4-Jun-87   05:44 PM                      CMD        CALC
```



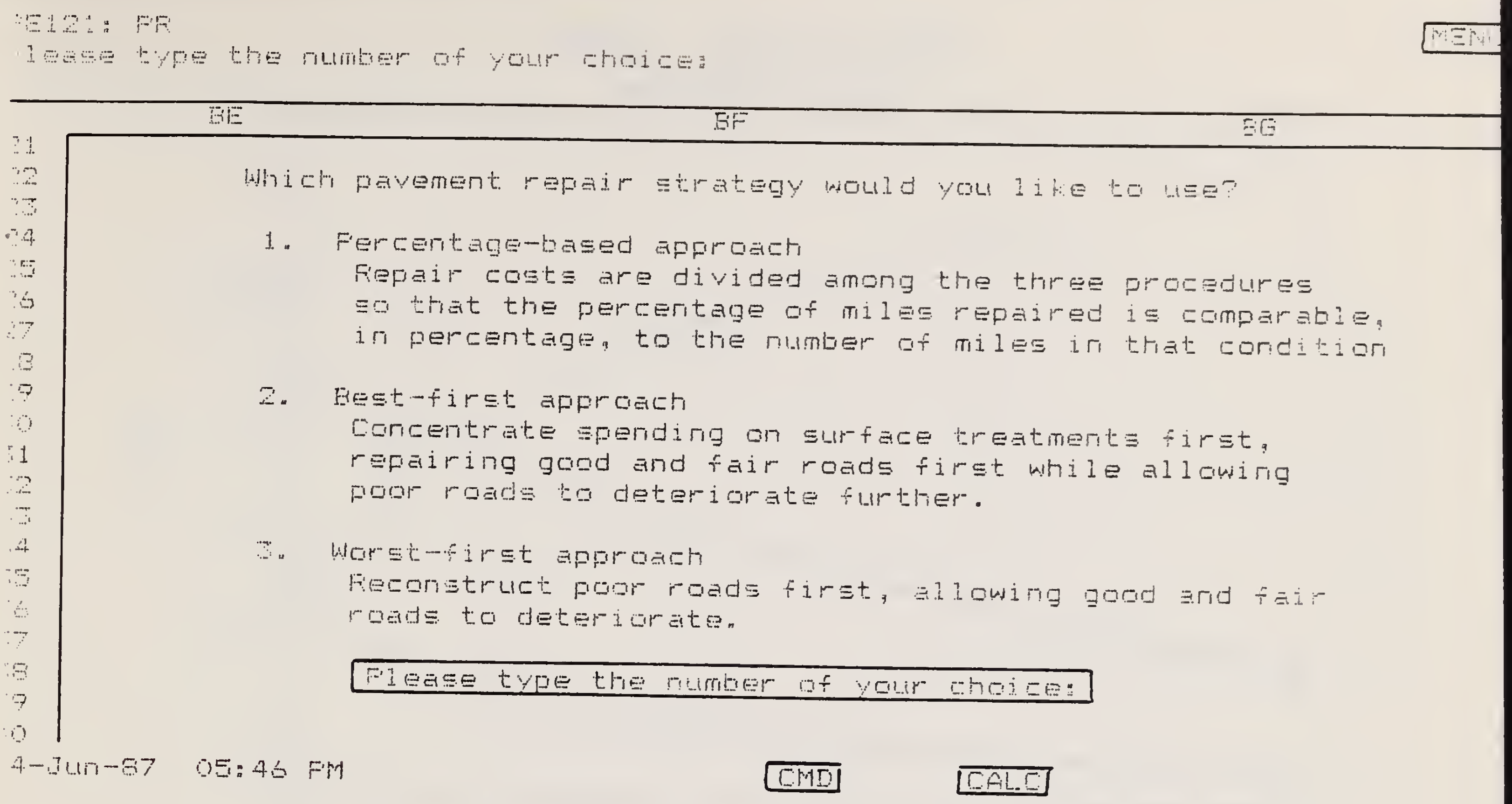
```
E121: PR                                                          MEN
lease type the number of your choice:

         BE                    BF                     BG

      How do you wish to enter the current road conditions?

                1.  By the number of road miles
                    in each condition

                              or

                2.  By the percentage of the total
                    road miles in each condition

             Please type the number of your choice:

4-Jun-87   05:45 PM                  CMD      CALC
```



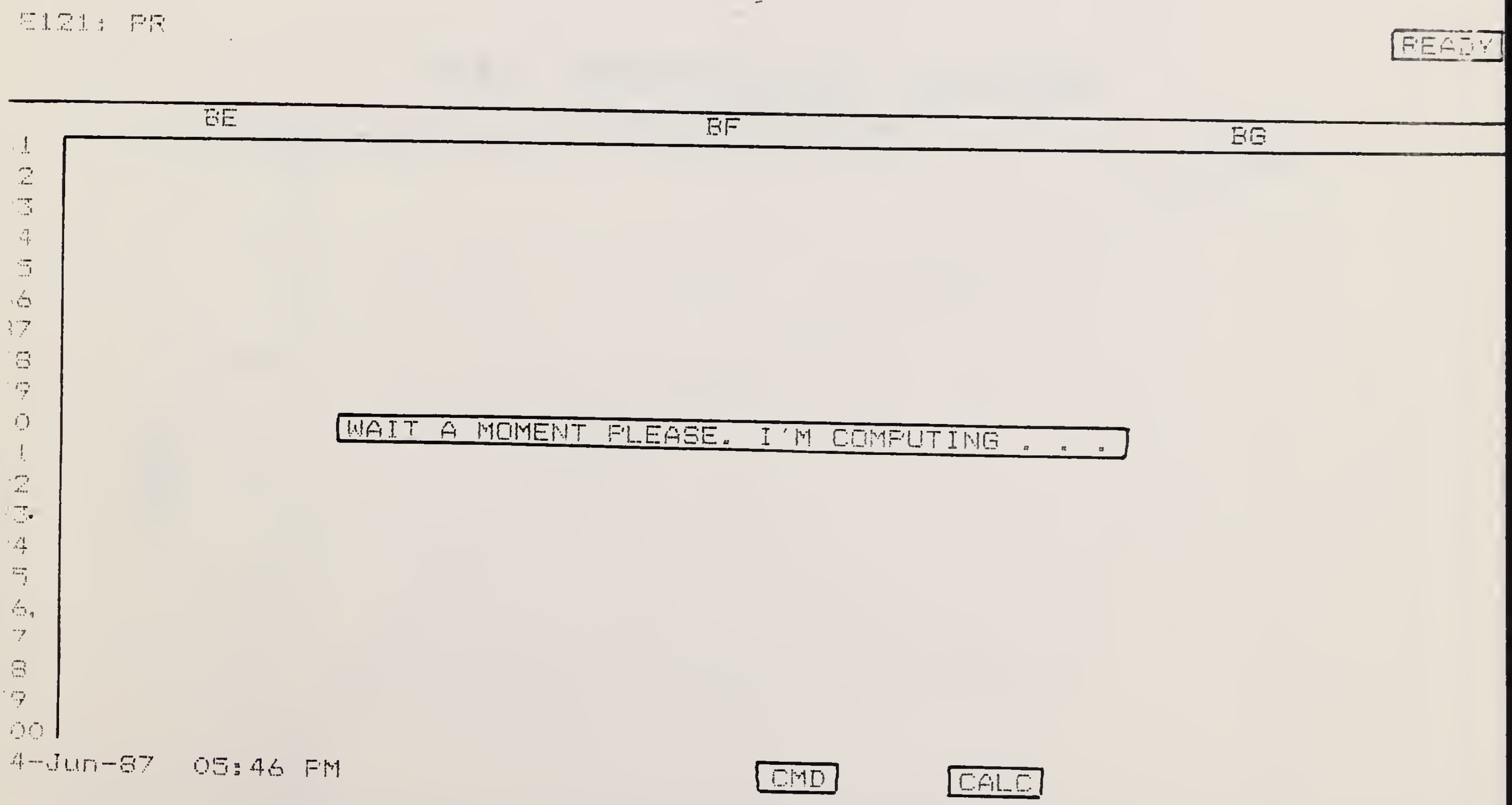
```
E121: PR                                                          INPUT
umber of road miles in excellent condition?

        AT          AU          AV          AW

                  CURRENT ROAD CONDITIONS
                  =======================
      Please enter estimates of the number of road miles in
        each condition (defined as follows):

      [Excellent - new or nearly new pavements with little distress]
      [Good - distress but few visible signs of deterioration]
      [Fair - moderate distress; riding quality noticeably inferior]
      [Poor - extensive distress or near complete failure]

                                    miles        % of total
      Excellent condition        [          ]
      Good condition                                    ERR
      Fair condition                                    ERR
      Poor condition                                    ERR
      ==================================================ERR==
       TOTAL                              0.00          ERR
4-Jun-87   05:45 PM                  CMD      CALC
```



```
E121: FR
Total number of road miles?

           AT                    AU                    AV                    AW

                    CURRENT ROAD CONDITIONS
                    =======================
     Please enter estimates of the percentage of the total road
        miles in each condition (defined as follows):

     [Excellent - new or nearly new pavements with little distress]
     [Good - distress but few visible signs of deterioration]
     [Fair - moderate distress; riding quality noticeably inferior]
     [Poor - extensive distress or near complete failure]

        TOTAL ROAD MILES        [              ] miles

                                 % of total         miles
     Excellent condition                             0.00
     Good condition                                  0.00
     Fair condition                                  0.00
     Poor condition                                  0.00
     ==================================================
      TOTAL                         0.00             0.00
6-Jun-87  04:48 AM               CMD       CALC        CAPS
```



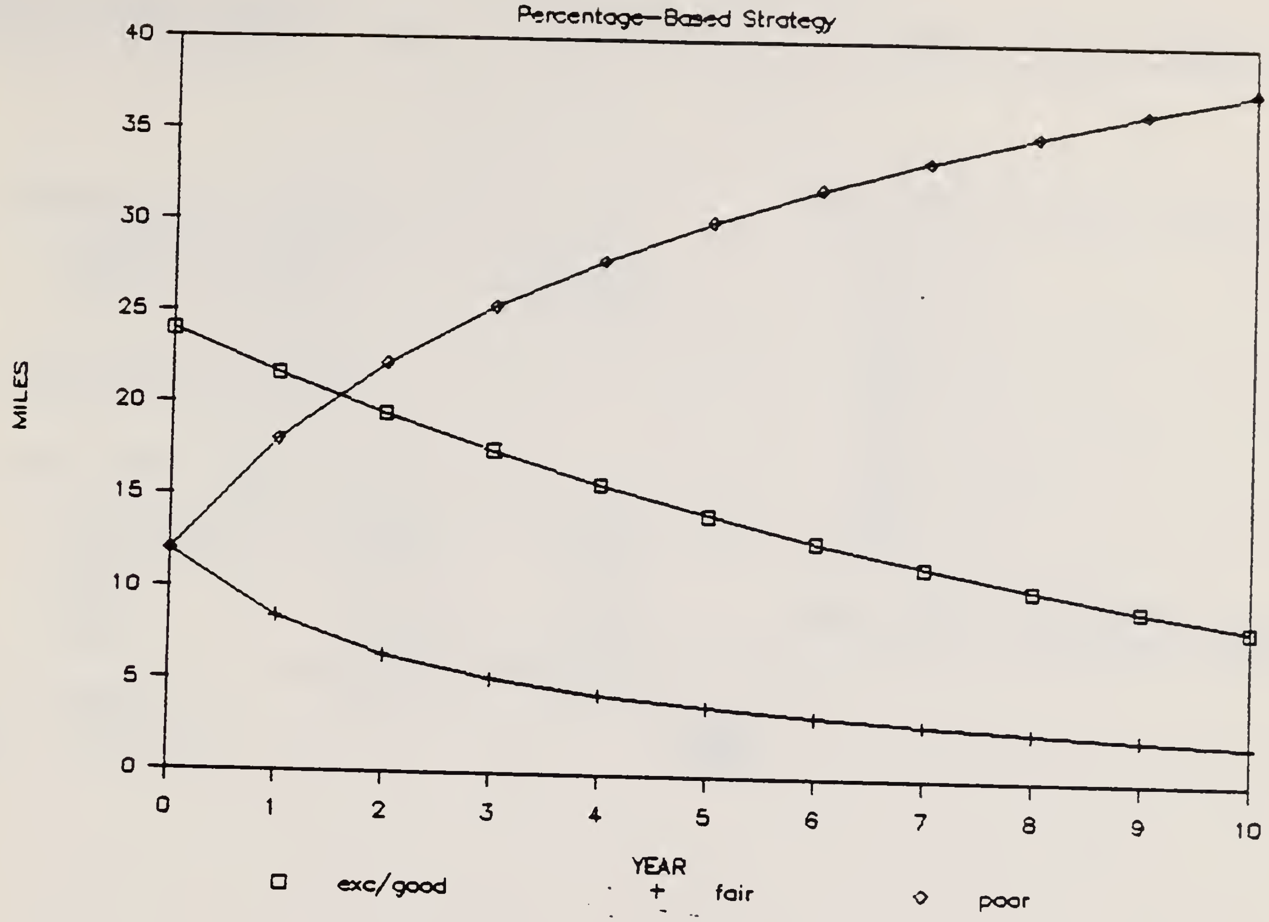
```
E121: PR
lease type the number of your choice:

        Which pavement repair strategy would you like to use?

         1.   Percentage-based approach
               Repair costs are divided among the three procedures
               so that the percentage of miles repaired is comparable,
               in percentage, to the number of miles in that condition

         2.   Best-first approach
               Concentrate spending on surface treatments first,
               repairing good and fair roads first while allowing
               poor roads to deteriorate further.

         3.   Worst-first approach
               Reconstruct poor roads first, allowing good and fair
               roads to deteriorate.

              Please type the number of your choice:

4-Jun-87   05:46 PM
```



```
E121: PR

         WAIT A MOMENT PLEASE. I'M COMPUTING . . .

4-Jun-87   05:46 PM
```

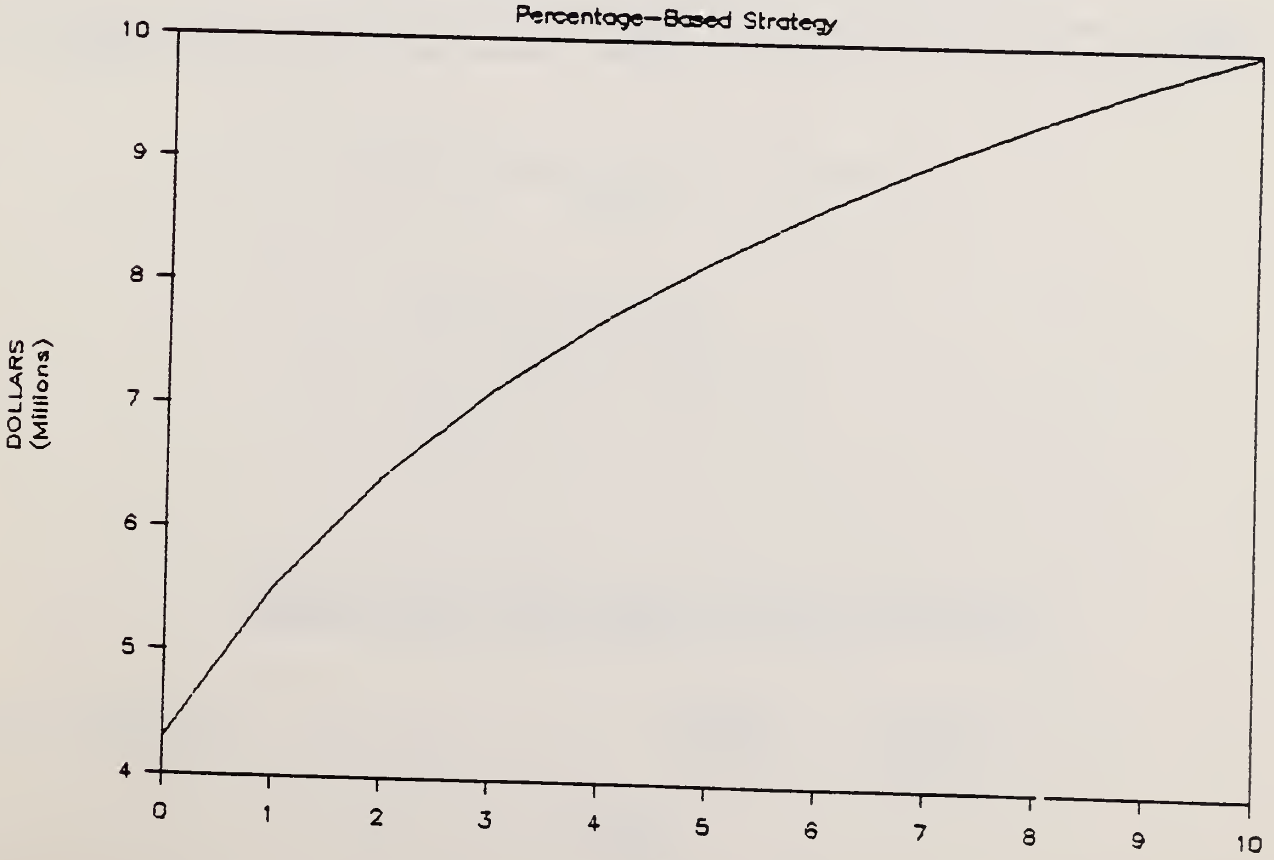
ROAD CONDITIONS

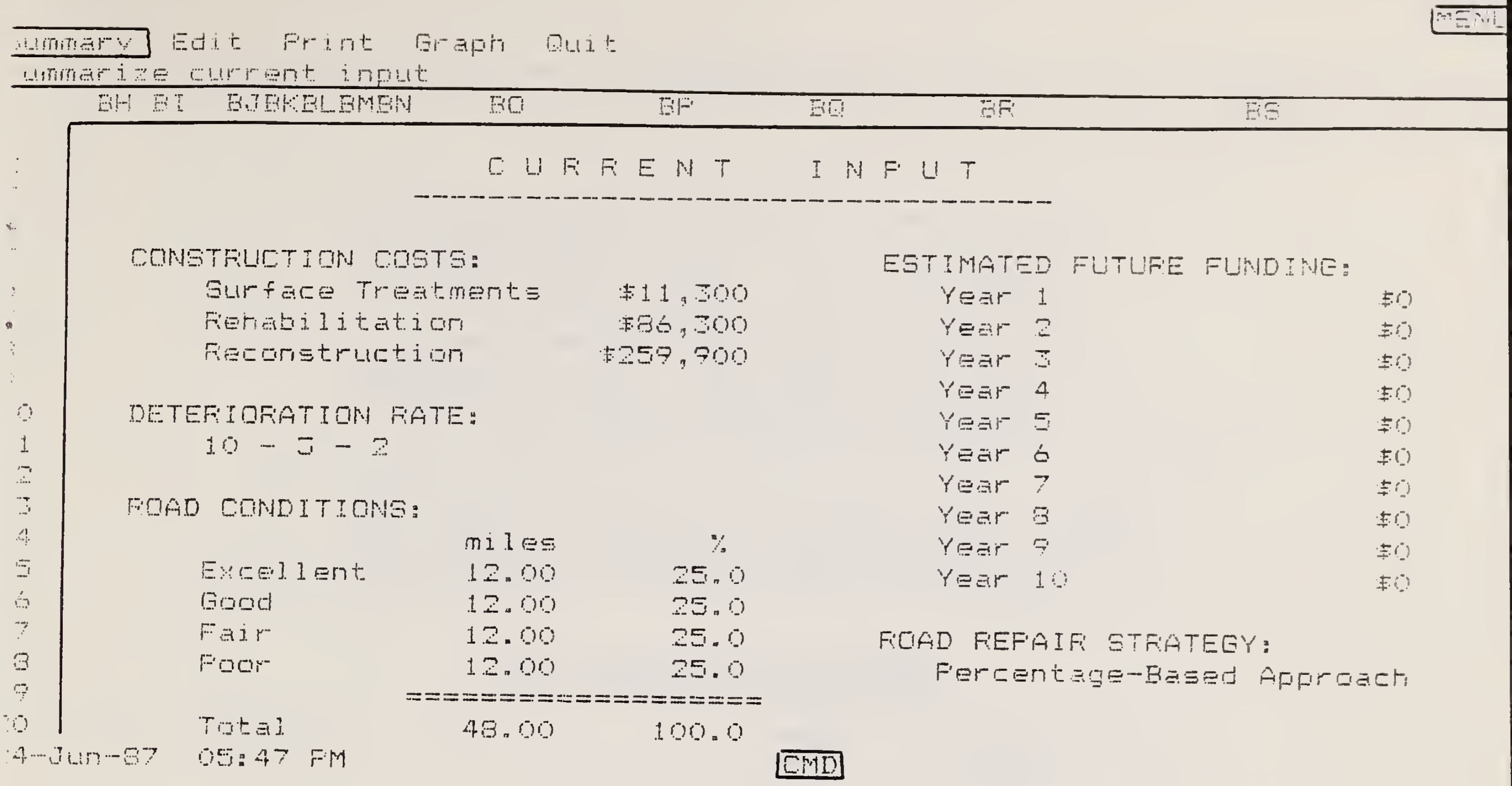
Percentage-Based Strategy



ROAD MAINTENANCE BACKLOG

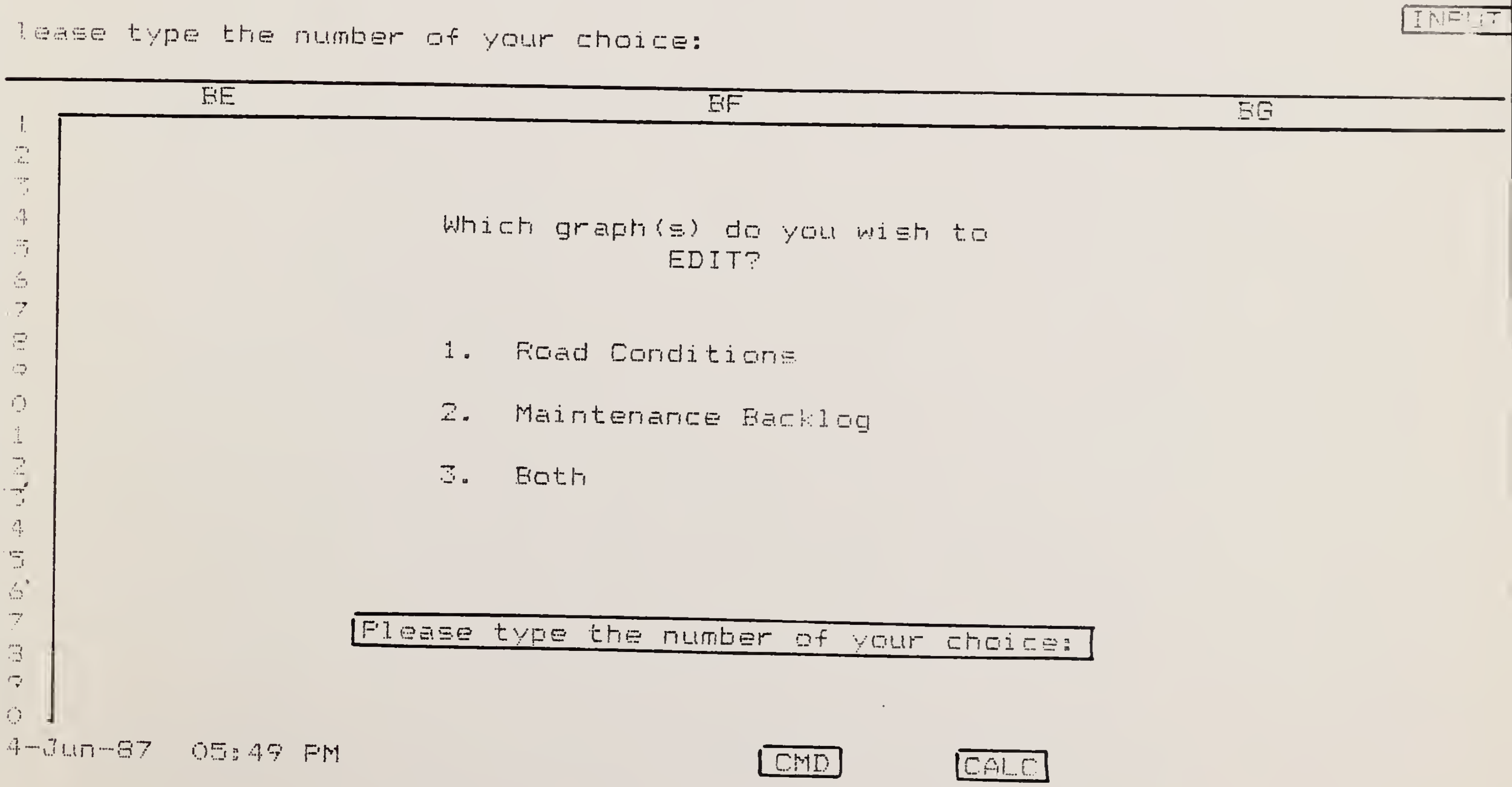
Percentage-Based Strategy



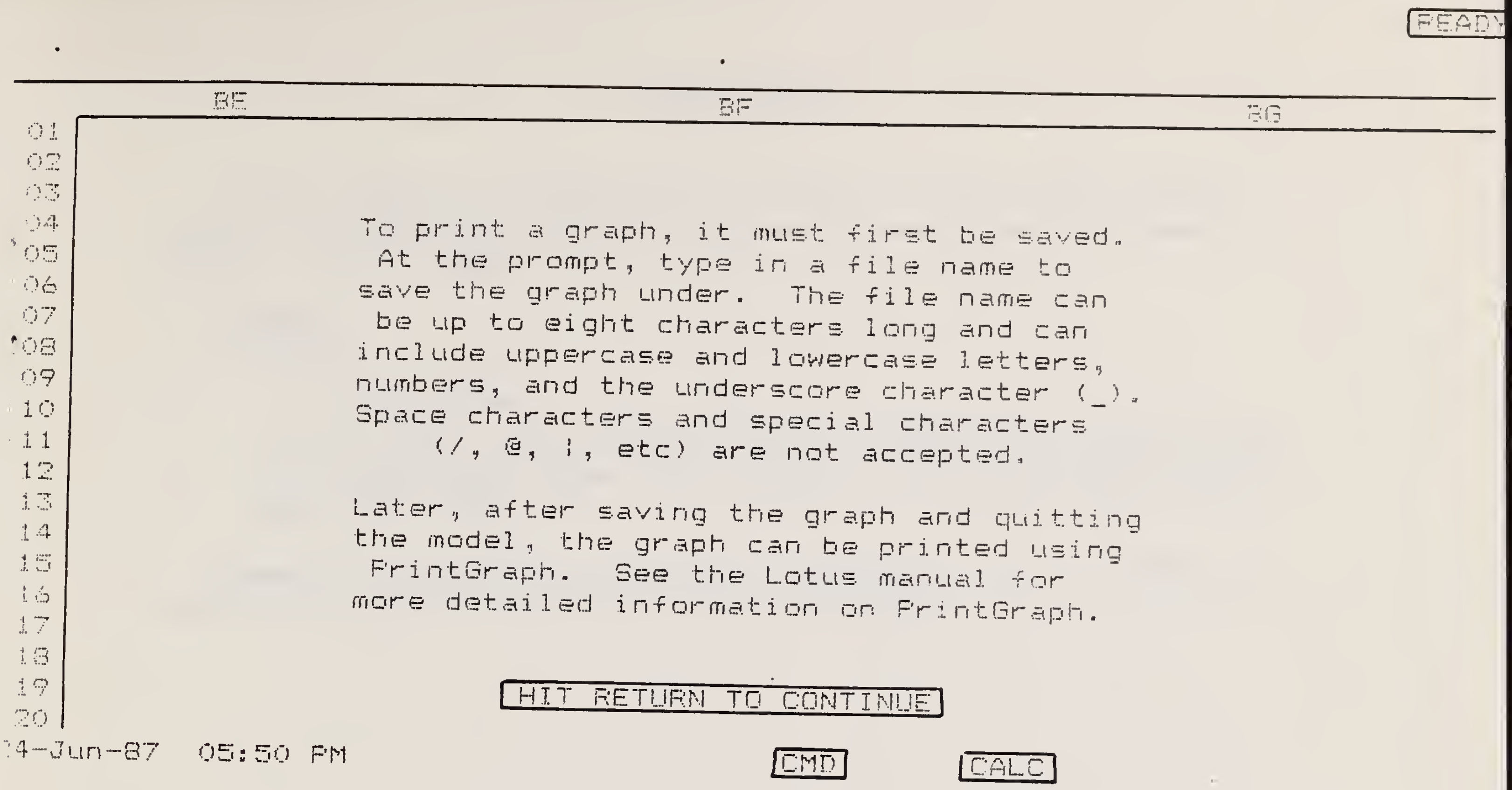


```
                        C U R R E N T     I N P U T
                        -------------------------------

 CONSTRUCTION COSTS:                          ESTIMATED FUTURE FUNDING:
     Surface Treatments      $11,300             Year  1                          $0
     Rehabilitation          $86,300             Year  2                          $0
     Reconstruction         $259,900             Year  3                          $0
                                                 Year  4                          $0
 DETERIORATION RATE:                             Year  5                          $0
     10 - 3 - 2                                  Year  6                          $0
                                                 Year  7                          $0
 ROAD CONDITIONS:                                Year  8                          $0
                        miles         %          Year  9                          $0
     Excellent          12.00       25.0         Year 10                          $0
     Good               12.00       25.0
     Fair               12.00       25.0      ROAD REPAIR STRATEGY:
     Poor               12.00       25.0         Percentage-Based Approach
                     ===================
     Total              48.00      100.0
4-Jun-87   05:47 PM
```

lease type the number of your choice:



```
                    Which graph(s) do you wish to
                              EDIT?

                    1.   Road Conditions

                    2.   Maintenance Backlog

                    3.   Both


            Please type the number of your choice:

4-Jun-87   05:49 PM
```



To print a graph, it must first be saved. At the prompt, type in a file name to save the graph under. The file name can be up to eight characters long and can include uppercase and lowercase letters, numbers, and the underscore character (_). Space characters and special characters (/, @, !, etc) are not accepted.

Later, after saving the graph and quitting the model, the graph can be printed using PrintGraph. See the Lotus manual for more detailed information on PrintGraph.

SAVING GRAPHS

Graphs produced by the model may be saved on a Drive other than the B Drive. To do so, simply type a path name as part of the file name in which to save the graph.

EXAMPLE:
Typing

```
C:\123\grphname
```

at the prompt asking for the graph file name would store the graph in a subdirectory named \123 on Drive C. (The subdirectory must be previously named.)

Remember to specify the Drive (and directory) in which the graphs are saved as the graphs-directory when using PrintGraph.